3rd EuroConference on Magnetic Properties of Fine Particles and their Relevance to Materials Science

Supported by the European Commission
DGXII, Human Potential Programme
High Level Scientific Conference (HPCF-1999-00138)

October 19th – 22nd, 1999
Barcelona

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CONFERENCE INFORMATION

Dates OCTOBER 19th - 22nd , 1999

Location

Torre D, edifici ***Les Cúpules***

Parc Científic de Barcelona

C/ Baldiri i Reixac 4 - 6, 08028 - Barcelona

Telph. (34) 93 403 45 09; Fax. (34) 93 403 45 10

Organisation

Group of Magnetism and Transport Properties

Department de Física Fonamental, Facultat de Física, Universitat de Barcelona

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Collaborating Institutions and Sponsorship (in order)

- European Commission
- Ministerio de Educación y Cultura. Dirección General de Enseñanza Superior e Investigación Científica
- Vicerrectorat de Recerca de la Universitat de Barcelona
- Divisió de Ciències Experimentals i Matemàtiques de la Universitat de Barcelona
- Generalitat de Catalunya. Comissionat per a Universitats i Recerca

MAIN TOPICS

- Dynamics and Interacting systems
- Macroscopic Quantum Tunneling in Small Particles and Molecular Magnets
- Magnetotransport Properties
- Applications and Devices
- New Preparation Techniques
- Theory, Modeling and Numerical Simulation
- Surface Properties
- Multiphase Materials
- Magnetic Nanostructures
- Biomagnetism

ORGANISING COMMITTE

- X. Batlle and A. Labarta (Co-chairs)
- M. García del Muro, O Iglesias, V. Franco and B.J. Hattink (Organisation)

Group of Magnetism and Transport Properties

Department de Física Fonamental, Facultat de Física, Universitat de Barcelona

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Group of Magnetism and Transport Properties,

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PRESENTATIONS

The Technical sessions will consist of invited talks and oral presentations. Invited talks will last 22 minutes, plus 3 minutes for questions, while oral presentations will last 12 minutes, plus 3 minutes for questions.

PUBLICATIONS

A selection of accepted papers will be published in an special issue of the **Journal of Magnetism and Magnetic Materials** devoted to the meeting. Papers must be handed to the organisers upon registration (October 19th) and will follow the regular standards and reviewing procedure of the Journal. All those accepted papers not in that selection or submitted later than the deadline will be published in later regular issues of the Journal and it will be highlighted that they were presented at the meeting.

Authors submitting a paper should provide 3 copies and an original set of figures, indicating the reference number of their presentation in the top right hand side corner of the first page.

PROGRAMME OVERVIEW

Tuesday 19th	Wednesday 20th
	Magnetotransport Properties 8:30-10:25 Chairman: G. Hadjipanayis
	COFFEE BREAK 10:25-10:55
	Macroscopic Quantum Tunneling in Small Particles and Molecular Magnets 10:55-13:20 Chairman: J. Tejada
REGISTRATION 13:30-14:30	**LUNCH** 13:20-15:00
OPENING 14:30-15:00	
Dynamics and Interacting Systems 15:00-17:00 Chairman: R. Chantrell	**Applications and Devices** 15:00-17:05 Chairman: A. Hernando
COFFEE BREAK 17:00-17:30	**COFFEE BREAK** 17:05-17:30
Macroscopic Quantum Tunneling in Small Particles and Molecular Magnets 17:30-19:30 Chairman: S. Morup	**Biomagnetism;** 17:30-17:55 Chairwoman: E. Tronc
	Properties and Characterization 17:55-19:05 Chairwoman: E. Tronc
WELCOME PARTY 19:30-20:00	

PROGRAMME OVERVIEW

Thursday 21st

Theory, Modelling and Simulation
8:30-10:35
Chairman: B. Barbara

COFFEE BREAK 10:35-11:00

Theory, Modeling and Simulation
11:00-12:10 Chairman: H. Krönmuller

Surface Properties
12:10-13:25
Chairman: A. Berkowitz

LUNCH
13:25-15:00

Multiphase Materials
15:00-17:05
Chairman: R. Shull

COFFEE BREAK 17:05-17:30

Magnetic Nanostructures
17:30-19:10
Chairman: K. O'Grady

CONFERENCE DINNER
21:00

Friday 22nd

Magnetic Nanostructures
9:00-10:20
Chairman: J. Chapman

COFFEE BREAK 10:20-10:50

Dynamics and Interacting Systems
10:50-12:40
Chairman: D. Fiorani

Multiphase Materials
12:40-13:40
Chairman: D. Fiorani

CLOSING REMARKS 13:40

DETAILED PROGRAMME

Tuesday October 19th – Afternoon

13:30-14:30 REGISTRATION
14:30-15:00 OPENING

- Dr. Marius Roviralta, Dean of Research of the Universitat de Barcelona and Vice-president of the Fundació Parc Científic de Barcelona.
- Dr. Xavier Testar, Director of the Centre d'Innovació *Les Cúpules* of the Fundació Bosch Gimpera of the Universitat de Barcelona.
- Dr. Xavier Batlle and Dr. Amílcar Labarta, Conference Co-chairs.

Dynamics and Interacting Systems

15:00-17:00
Chairman: R. Chantrell

15:00

I1 Superparamagnetic Relaxation Modes And Inter-Particle Interactions In Samples Of Hematite Nanoparticles.

S.Mørup, F. Bødker and M.F. Hansen
Department of Physics, Technical University of Denmark, DK-2800 Lyngby, Denmark

15:25

I2 Collective Dynamics in Dense Ferrofluids

Per Nordblad[a], Petra Jönsson[a], Mikkel Fougt Hansen[a,b], Peter Svedlindh[a]
[a] Department of Materials Science, P.O. Box 534, Uppsala University, SE-751 21 Uppsala, Sweden
[b] Department of Physics, Building 307, Technical University of Denmark, DK-2800 Lyngby, Denmark

15:50

I3 Dynamics of γ–Fe_2O_3 Nanoparticle Systems

D. Fiorani[1], L. Spinu[2], F. Lucari[3], F.D'Orazio[3], E. Tronc[4], M. Nogues[5], A.M. Testa[6]
[1] I.C.MAT-CNR, Area della Ricerca di Roma, C.P. 10, 00010 Monterotondo Stazione (Italy)
[2] Faculty of Physics, Alexandra Ioan Cuza University, Blv. Copou 11, Iasi 6600, Romania
[3] INFM-Dip. di Fisica, Università, 67100 L'Aquila, Italy
[4] LCMC, Université P. et M. Curie, 75252 Paris Cedex 05, France
[5] LMOV, CNRS, Université de Versailles, 78035 Versailles Cedex, France

16:15

O1 Dynamical Properties of Non-Interacting Co Nanoparticles Embedded in a Polymer

M. Respaud,[a] J.M. Broto,[a] M. Goiran,[a] L. Thomas,[b] F. Lionti,[b] B. Barbara,[b] T. O. Ely,[c] C. Amiens,[c] B. Chaudret,[c]

[a] *LPMC, SNCMP, Insa, Complexe Scientifique de Rangueil, 31077 Toulouse.*

[b] *Laboratoire Louis Néel, 25 av. des Martyrs, 38042 Grenoble.*

[c] *Laboratoire de Chimie de Coordination, 205 route de Narbonne, 31077 Toulouse.*

16:30

O2 Effect of Interparticle Interactions in $(Fe_{0.2}Ni_{0.8})_{100-y}B_y$ Magnetic Nanoparticles

D. Zysler[1], C. A. Ramos[1], E. De Biasi[1], H. Romero[2], A. Ortega[2], D. Fiorani[3]

[1] *Centro Atómico Bariloche and Instituto Balseiro, 8400 S. C. de Bariloche, RN, Argentina.*

[2] *Dpto. de Física, Fac. de Ciencias, Universidad de Los Andes, Mérida, Venezuela.*

[3] *ICMAT-CNR, Area della Ricerca di Roma, C.P. 10, I-00016 Monterotondo Staz., RM, Italia.*

16:45

O3 Magnetic viscosity study of thin flexible RE Magnet-Foils

J.M. Torres Bruna(*), L.M. García(*), J. Bartolomé(*), Rodewald W(⊠).

(*) Instituto de Ciencia de Materiales de Aragón, CSIC-Universidad de Zaragoza, 50009 Zaragoza, Spain

(⊠) Vacuumschmelze GmbH, P.O. Box 2253, D 63412 Hanau, Germany

17:00-17:30 COFFEE BREAK

Macroscopic Quantum Tunneling in Small Particles and Molecular Magnets

17:30-19:30

Chairman: S. Morup

17:30

I4 Mesoscopic Quantum Coherence in Molecular Clusters

J. Tejada, J. M. Hernandez, E. del Barco and E. M. Chudnovsky

Fac. Física , Universitat Barcelona, Barcelona, SPAIN

J. Brooks and N.Biskup

Dept. of Physics, National High Magnetic Field Lab., Univ. of Florida, Tallahassee, Florida USA.

17:55

I5 Macroscopic Quantum Tunneling in Molecular Magnets

B. Barbara, I. Chiorescu, W. Wernsdorfer, L. Thomas, F. Lionti, A. Müller [a], D. Gatteschi [b].
Laboratoire de Magnétisme Louis Néel, CNRS, BP166, 38042 Grenoble, Cedex-09, France
[a] *Fakültat für Chemie, Universität Bielefeld, D-33501 Bielefeld, Germany*
[b] *Dept. of Chemistry, Univ. of Firenze, 50144, Italy.*

18:20

I6 Molecular Magnetic Clusters

Dante Gatteschi and Roberta Sessoli
Department of Chemistry, University of Florence, Florence, Italy

18:45

O4 Secondary Relaxation Regimes in Mn_{12} Organic Cluster Compounds

Marco Evangelisti and Juan Bartolomé
Instituto de Ciencia de Materiales de Aragón, C.S.I.C. – Universidad de Zaragoza, E-50009 Zaragoza, Spain

19:00

O5 Field-Dependence of the Magnetic Relaxation in Mn12-Acetate

Yicheng Zhong, M.P. Sarachik
(City College of New York)
Daniel Ruiz, D.N. Hendrickson
(University of California, San Diego)

19:15

O6 Hall Magnetometry Studies of Molecular Magnet Fe_8 Single Crystals

Louisa Bokacheva, Andrew D. Kent, Department of Physics and Marc Walters
Department of Chemistry, New York University, New York, NY 10003

19:30 WELLCOME PARTY

Wednesday October 20th – Morning

Magnetotransport Properties

8:30-10:25
Chairman: G. Hadjipanayis

8:30

I7 Magnetic Nanoparticles in Insulating Matrices

E. Berkowitz and Sandra Sankar
Physics Department and Center for Magnetic Recording Research, University of California at San Diego, La Jolla California 92093-0401.
David J. Smith and M. R. McCartney
Center for Solid State Science, Arizona State University, Tempe, Arizona 85287-1704.

8:55

I8 Low Field Magnetoresistance in Fine Particles of $La_{0.67}Ca_{0.33}MnO_3$ Perovskites

J. Rivas[a], L.E. Hueso[a], A. Fondado[a], F. Rivadulla[b], and M.A. López-Quintela[b]
[a]Departamento de Física Aplicada and b Departamento de Química-Física, Universidad de Santiago de Compostela, España

9:20

I9 Interplay of Spin Dependent Tunneling and Coulomb Blockade In Co Clusters Based Tunnel Junctions

J. Briatico, J. Carrey, V. Cros, J-L. Maurice, F. Petroff , A. Vaurès and A. Fert
Unité mixte CNRS/Thomson-LCR, Domaine de Corbeville, 91404 Orsay, France
C. Vouille and G. Faini
L2M-CNRS, B.P.107, 92225 Bagneux, France
T. Cren and D. Roditchev
Groupe de Physique des Solides, Université Paris VI-VII, 75455 Paris, France
J. Barnas
Magnetism Theory Division, Institute of Physics, Adam Mickiewicz University, 61-614 Poznan, Poland

9:45

I10 Domain Structures and Training Effects in Granular Thin Films

V. Franco, X. Batlle and A. Labarta
Dept. Física Fonamental, Universitat de Barcelona, Diagonal 647 08028 Barcelona, Spain.

10:10

O7 Tunneling Magnetoresistance of Granular Films Made of Well Defined Co Clusters Embedded in an Inert-Gas Matrix

M.Holdenried and H. Micklitz
Physikalisches Institut, Universität zu Köln, Zülpicher Str. 77, 50937 Köln, Germany.

10:25-10:55 COFFEE BREAK

Macroscopic Quantum Tunneling in Small Particles and Molecular Magnets

10:55-13:20
Charmain: J. Tejada

10:55

I11 Magnetization Reversal Studied in Single Nanometer-Sized Particles and Clusters

W. Wernsdorfer[1], E. Bonet Orozco[1], B. Barbara[1], A. Benoit[2], and D. Mailly[3]
(1) LL Néel – CNRS, BP166, 38042 Grenoble, France
(2) CRTBT – CNRS, BP166, 38042 Grenoble, France
(3) LMM – CNRS, 196 Av. H. Ravera, 92220 Bagneux, France

11:20

I12 Disentangling Distribution Effects and Nature of the Dynamics in Relaxation Measurements: The RMR Method

R. Sappey, E. Vincent, M. Ocio, J. Hammann
Service de Physique de l'Etat Condensé, CEA Saclay, 91191 Gif-sur-Yvette Cedex, France

11:45

I13 Evidence for a First Order Transition Between Quantum and Thermally Assisted Tunneling in a Molecular Magnet

Andrew D. Kent*, Yicheng Zhong†, Louisa Bokacheva*, Daniel Ruiz‡ ,David N. Hendrickson‡ and Myriam P. Sarachik†
**Department of Physics, New York University, †Department of Physics, CCNY, ‡Department of Chemistry and Biochemistry, UCSD.*

12:10

I14 Thermally Activated Magnetic Quantum Tunnelling at Zero Field in Magnetic Clusters and Small Particles.

J. Bartolomé, F. Luis, J. Fernández.
ICMA - CSIC-University of Zaragoza, 50009, Spain

12:35

O8 Non-adiabatic Landau-Zener transitions in low spin molecular magnet V_{15}

I. Chiorescu [a], W. Wernsdorfer [a], A. Müller [b], H. Bögge [b] and B. Barbara [a]
[a] Laboratoire de Magnétisme Louis Néel, CNRS, BP 166, 38042-Grenoble, France.
[b] Fakültat für Chemie, Universität Bielefeld, D-33501 Bielefeld, Germany.

12:50

O9 Phonon-Avalanches and Time Dependent Heat Capacity in Mn_{12} Clusters

J. M. Hernández, E. del Barco, M. Sales and J. Tejada
Fac. Física, Universitat de Barcelona. Barcelona 08020, SPAIN.

13:05

O10 Quantum Relaxation in the Magnetic Molecular Cluster Fe_8.

V.Villar[1], T.Ohm[1], C. Sangregorio[3], W.Wernsdorfer[2], A. Cornia[3], R.Sessoli[3],G. Gatteschi[3], C. Paulsen[1]
(1) CRTBT - CNRS, BP166, 38042 Grenoble, France
(2) LL Néel - CNRS, BP166, 38042 Grenoble, France
(3) Dept. of Chem., Univ. of Florence, 50144 Firenze, Italy

13:20-15:00 LUNCH

Wednesday October 20th – Afternoon

Applications and Devices

15:00-17:05
Chairman: A. Hernando

15:00

I15 Magnetic Particle Nanocomposite Refrigerants

R.D. Shull, R.D. McMichael, J.J. Ritter
Materials Science and Engineering Laboratory, National Institute of Standards and Technology, Gaithersburg, MD 20899

15:25

I16 CoPt and FePt Granular Films for Magnetic Recording Media

George C. Hadjipanayis, Y. Zhang, and J. A. Christodoulides
Department of Physics and Astronomy, University of Delaware, Newark, DE 19716
S. Stavroyiannis, I. Panagiotopoulos, and D. Niarchos
IMS, NCSR "Demokritos," Ag. Paraskevi Attiki, 153 10 Greece

15:50

I17 Recent Developments in Metal Particle Technology for Flexible Recording Media

K. O'Grady, J. A. Hutchings and J. J. Blackwell
SEECS, University of Wales Bangor, Bangor, Gwynedd. LL57 1UT. UK

16:15

I18 Room-Temperature Magnetoresistive Sensor Based on Thick Films Manganese Perovskite

Ll. Balcells, and J. Fontcuberta
Institut de Ciència de Materials de Barcelona, Consejo Superior de Investigaciones Científicas, Campus UAB, Bellaterra 08193, Calalunya, Spain.

16:40

I19 Alkali Metal Cation Effects in Hydrogen-Type Aqueous Ferrofluids for Color Printting

R. Ziolo and R. Pieczynski
University of Barcelona. Xerox Laboratory for Magnetic Research, Av. Diagonal 647, 08028 Barcelona. Spain.
S. Majetich
Department of Physics, Carneige Mellon University, Pittsburg, PA 15217.

17:05-17:30 COFFEE BREAK

Biomagnetism

17:30-17:55
Chairwoman: E. Tronc

17:30

I21 Magnetotactic Bacteria

J.M. Ruiz, J. Tejada, M. Durán
Dept. Física Fonamental, Universitat de Barcelona, Diagonal 647, 08028 Barcelona. Spain

Preparation and Characterization

17:55-19:05
Chairwoman: E. Tronc

17:55

I22 New Routes for the Preparation of Uniform Magnetic Particles

C.J. Serna and M.P. Morales
Instituto de Ciencia de Materiales de Madrid, CSIC. 28049-Cantoblanco, Madrid (Spain)

18:20

O11 Bimetallic Nanoscale Magnetic Particles In Organic Matrices

T Ould Ely[a], Cheng Pan[a], C. Amiens[a], B. Chaudret[a], F. Dassenoy[b], P Lecante[b], M-J Casanove[b], A. Mosset[b], M. Respaud[c], J-M. Broto[c]

[a]*LCC/CNRS, 205 Route de Narbonne, 31077 Toulouse Cedex*

[b]*CEMES, 29 rue J. Marvig, 31055 Toulouse Cedex*

[c]*IPS-INSA, 31077 Toulouse Cedex*

18:35

O12 Structural evolution of Co clusters in $Co_{15}Cu_{85}$ granular alloys by EXAFS spectroscopy

A. García Prieto[1], M.L. Fdez-Gubieda[1], A. García-Arribas[1], P. Gorria[2], I. Orue[2], J.M. Barandiarán[1], C. Meneghini[3], S. Mobilio[3]

[1]*Departamento de Electricidad y Electrónica. Universidad del País Vasco. Apartado 644. 48080 Bilbao. Spain.*

[2]*Departamento de Física. Universidad de Oviedo. Av. Calvo Sotelo, s/n, 33007 Oviedo Spain.*

[3]*Laboratori Nazionali di Frascati (INFN) P.O. Box, I-00044 Frascati, Italy.*

18:50

O13 Grazing-incidence x-ray measurements of granular recording media

H. Laidler and L. Holloway

Magnetic Materials Research Group, University of Wales, Bangor, Gwynedd, LL57 1UT, UK.

Thursday October 21st – Morning

Theory, Modeling and Simulation

8:30-12:10

Chairman: B. Barbara

8:30

I23 Computational Studies of the Susceptibility of Interacting Fine Particle Systems

R.W. Chantrel, N.S. Walmsley, J. Gore and M. Maylin

SEES, University of North Wales, Bangor, UK.

8:55

I24 The Microstructure and Magnetisation Processes in Nanocrystalline Systems

H. Kronmüller, M. Bachmann, R. Hertel and T. Leineweber

Max-Planck-Institut für Metallforschung, Heisenbergstr. 1, D-70569 Stuttgart, Germany

9:20

I25 Simulation of Thermally Activated Switching in Fine Particles

W. Scholz, T. Schrefl and J. Fidler
Institute of Applied and Technical Physics,Vienna University of Technology,Wiedner Hauptstr. 8-10/137, A-1040 Vienna, Austria.

9:45

I26 Hysteresis and avalanches in frustrated and disordered systems

Eduard Vives and Antoni Planes
Departament d'Estructura i Constituents de la Matèria, Facultat de Física, Universitat de Barcelona, Diagonal 647, 08028 Barcelona, Catalonia.

10:10

I27 Asymptotic Formula for the Neel Relaxation Time Valid for all Values of the Damping Parameter.

W.T. Coffey, D.A. Garanin, E.C. Kennedy, and D.P. McCarthy.
Trinity College Dublin, Ireland..

10:35-11:00 COFFEE BREAK

11:00

O14 Magnetic history dependence of metastable states in systems with dipolar interactions.

O. Iglesias and A. Labarta
Dept. Física Fonamental, Universitat de Barcelona, Diagonal 647, 08028 Barcelona, Spain.

11:15

O15 Micromagnetic modelization of thermal magnetization decay for interacting systems.

O.A.Chubykalo, B.Jones, B.Lengthfield, J.Kauffman
Almaden Research Center, IBM, San Jose, CA, USA
J.M.González
Instituto de Ciencia de Materiales de Madrid, CSIC, Cantoblanco, Madrid, Spain
R.W.Chantrell, R.Smirnov-Rueda
School of Electronic Engineering, University of Wales, Bangor, UK

11:30

O16 Monte Carlo Investigation of Magnetic Properties in Fe/Tb Multilayers

L. Veiller, D. Ledue and J. Teillet
Magnétisme et Applications, GMP, UMR 6634 CNRS-Université de Rouen, 76821 Mont-Saint-Aignan Cédex, FRANCE

11:45

I20 **Dipolar Interactions Induced Order in Assemblies of Magnetic Particles**

Pastor-Satorras R., Rubí J.M.
Dep. Física Fonamental, Universitat de Barcelona, Av. Diagonal 647, 08028 Barcelona, Spain.

Surface Properties

12:10-13:25
Chairman: A. Berkowitz

12:10

I28 Adsorption and Surface Properties of γ–Fe_2O_3 Nanoparticles

E. Tronc[1], A. Ezzir[2], R. Cherkaoui[2], C. Chanéac[1], M. Noguès[2], H. Kachkachi[2], J.P. Jolivet[1]
[1] LCMC, CNRS-UMR 7574, UPMC, T54-E5, 4 Place Jussieu, 75252 Paris cedex 05, France
[2] LMOV, CNRS-UMR 8634, UVSQ, 45 av. des Etats Unis, 78035 Versailles cedex, France

12:35

I29 Surface-related effects on the magnetic properties of γ-Fe_2O_3 nanoparticles

B. Martínez.
Instituto de Ciencia de Materiales de Barcelona-CSIC, Campus UAB, Bellaterra 08193. Spain.

13:00

I30 Surface Effects in Nanoparticles

H. Kachkachi[1], A. Ezzir[1], M. Noguès[1] and E. Tronc[2]
[1]LMOV-CNRS UMR 8634, Université de Versailles St . Quentin, 45 avenue des Etats-Unis, 78035 Versailles Cedex, France
[2]LCMC-CNRS URA 1466, Université Pierre & Marie Curie, 4 place Jussieu, 75252 Parix Cedex, France

13:25-15:00 LUNCH

Thursday October 21st – Afternoon

Multiphase Materials

15:00-17:05
Chairman:R. Shull

15:00

I31 Thermal Dependence Of Coercivity In Co-based Nanostructures.

A. Hernando, A. González, J. M. González, A. Salcedo.
Instituto de Magnetismo Aplicado (RENFE, UCM), PO Box 155, 28230 Las Rozas, Madrid, Spain.

15:25

I32 Ferromagnetic Resonance Studies of Multiphase Ferromagnets

J.M. Barandiarán and D.S. Schmool*
Departamento de Electricidad y Electronica, Universidad del Pais Vasco (UPV/EHU), Apartado 644, E-48080 BILBAO (Spain)
[*]Dpt. of Physics, University of Exeter, Stocker Road, Exeter, EX4 4QL, U.K.

15:50

I33 Magnetic Behavior, Domain Dynamics and Microstructure in the $Fe_{13.1}Nd_xB$ Fine-Particle System

Kannan M. Krishnan, E. Girt, G. Thomas, Z. Althunian* and T. Schrefl**
Materials Sciences Division, Lawrence Berkeley National Laboratory, University of California, Berkeley, CA 94720
**Department of Physics, McGill University, Canada*
***Institut fur Angewandte und Technische Physik, T. U. Wien, Austria*

16:15

I34 Magnetism and Structural Features of Glass Coated Cu-based (Co,Fe,Ni-Cu) Microwires.

J. González, A. Zhukov, J.J. Del Val[1], J.M. Blanco*, E.Pina** and M. Vázquez**
Department of Materials Physics, Faculty of Chemistry, UPV,P.O. Box 1072, 20080 San Sebastián, Spain
[1]Dpt. Materials Physics, Fac. Chemistry and Centro Mixto CSIC-UPV/EHU, 20080 San Sebastián, Spain
**Departamento de Fisica Aplicada I, EUITI, UPV, Avda Felipe IV 1B, 20011, San Sebastián Spain.*
***Instituto de Magnetismo Aplicado, RENFE-UCM-CSIC, P.O. Box 155, 28230, Las Rozas, Spain*

16:40

I35 On The Hysteresis And Relaxation Of Hard-Soft Nanocomposite Samples

J.M. González[a,b], M.I. Montero[a] and A. Hernando[b]
[a] *Instituto de Ciencia de Materiales de Madrid – CSIC. Cantoblanco, 28049 Madrid, Spain*
[b] *Instituto de Magnetismo Aplicado. P.O. Box 155, 28230 Las Rozas (Madrid), Spain*

17:05-17:30 COFFEE BREAK

Magnetic Nanostructures

17:30-19:10
Chairman: K. O'Grady

17:30

I36 TEM Observations of the Response of Small Magnetic Elements to an Applied Field

J N Chapman
Department of Physics and Astronomy, University of Glasgow, Glasgow G12, United Kingdom

17:55

I37 The Physics of Arrays of Submicron Magnetic Nanostructures

Ivan K. Schuller
Physics Department, University of California-San Diego, La Jolla, Ca. 92093-0319

18:20

I38 Ordered Nanometric Ferromagnetic Tiles, Lines and Dots: a New Tool to Modify Magnetic Properties

J. L. Vicent
Departamento de Física de Materiales, Facultad de CC. Físicas, Universidad Complutense, 28040 Madrid (Spain)

18:45

I39 Magnetic Nanostructures on Vicinal Single Crystal Surfaces

J. Elmers
Universität Mainz, Institut für Physik, 55099 Mainz, Germany

21:00 CONFERENCE DINNER

Friday October 22nd – Morning

Magnetic Nanostructures

9:00-10:20
Chairman: J. Chapman

9:00

I40 Magnetic Force Microscopy in the presence of a Rotating Magnetic Field

C. Van Haesendonck, A. Volodin, K. Temst, Y. Bruynseraede
Laboratorium voor Vaste-Stoffysica en Magnetisme, Katholieke Universiteit Leuven, Celestijnenlaan 200 D, B-3001 Leuven, Belgium

9:25

I41 Manipulating the Onset of the Magnetization Reversal in Magnetic Nanowires

K. Ounadjela, U. Ebels, A. Radulescu, Y. Henry, L. Piraux
IPCMS, 23 rue du Loess, 67037 Strasbourg, France
UCL, Louvain, Belgium

9:50

O17 Engineering the Hysteresis Properties of Thin Films by Lithographically defined non-Magnetic Nanostrutures: A Micromagnetic Study.

L. Torres, L. López-Díaz and J. Íñiguez**.**
Departamento de Física Aplicada. Universidad de Salamanca.
Plaza de la Merced s/n 37008. Salamanca. Spain.

10:05

O18 Magnetic Domain Structure in Ni (001) Sub-micron Particles

M. Hanson
Department of Experimental Physics, Chalmers University of Technology and Göteborg University, S-412 96 Göteborg, Sweden
B. Nilsson
Department of Microelectronics and Nanoscience, Chalmers University of Technology and Göteborg University, S-412 96 Göteborg, Sweden
E. B. Svedberg
Material Physics, Department of Physics, Linköping University, S-581 83 Linköping, Sweden

10:20-10-50 COFFEE BREAK

Dynamics and Interacting Systems

10:50-12:40

Chairman: D. Fiorani

10:50

I42 Magnetic Dynamics of Fine Particles Studied by Inelastic Neutron Scattering

M.F. Hansen[a], F. Bødker[a], S. Mørup[a], K. Lefmann[b], K.N. Clausen[b], P.-A. Lindgård[b]

[a]*Department of Physics, Building 307, Technical University of Denmark, DK-2800 Lyngby, Denmark*

[b]*Department of Condensed Matter Physics and Chemistry, Risø National Research Center, DK-4000 Roskilde, Denmark*

11:15

I43 Glassy Behaviour in Small Particle Systems

M. García del Muro, X. Batlle and A. Labarta

Dept. Física Fonamental, Universitat de Barcelona, Diagonal 647, 08028 Barcelona, Spain.

11:40

O19 Superparamagnetic Relaxation And The Effect of Inter-Particle Interactions For NiO Nanoparticles.

F. Bødker, Steen Mørup and M.F. Hansen,

Department of Physics, Technical University of Denmark, DK-2800 Lyngby, Denmark

11:55

O20 Modeling of Interaction Effects in Granular Systems

M. El-Hilo, M. Shatnawy and A. Al-Rsheed

Dept. of Physics, Al al-Bayt University, PO Box 130040, Mafraq, Jordan

12:10

O21 Effect of Interparticle Interactions in Nanosized α-Fe_2O_3 /Al_2O_3 System

D.Fiorani [1], A.M.Testa [1], R.D.Zysler [2]

[1] *ICMAT-CNR, Area della Ricerca di Roma, (Rome), Italy*

[2] *Centro atómico Bariloche, 8400 S.C. de Bariloche, RN*

12:25

O22 Thermal Effects and Anisotropy in Particles for Magnetic Recording Media

G. Bottoni, D. Candolfo and A. Cecchetti

Dept. of Physics, University of Ferrara, 44100 Ferrara, Italy.

Multiphase Materials

12:40-13:40

Chairman: D. Fiorani

12:40

O23 Magnetic Behaviour And Percolation In Mechanically Alloyed Fe SiO_2 Granular Solids

J.J. Blackwell,[a] M. Alonso-Sañudo,[c] K. O'Grady,[a] J.M. González,[b] F. Cebollada,[c] and P. Morales.[b]

[a] *Magnetic Materials Group. SEECS. University College of North Wales. Bangor, LL57-1UT. UK.*

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[c] *Dep. de Física Aplicada a las T.I. EUIT de Telecomunicación-UPM. Cra. de Valencia, km 7. 28031 Madrid. Spain.*

12:55

O24 Enhancement Of Room Temperature Coercivity By Mechanical Alloying Ferromagnetic And Antiferromagnetic Materials

J. Sort, J. Nogués, X. Amils, S. Suriñach, J.S. Muñoz, M.D. Baró

Dept. de Física, Univ. Autònoma de Barcelona, 08193 Bellaterra, Spain

13:10

O25 Magnetic and Electromagnetic Properties of Superparamagnetic Nanocomposites.

Cyrille Desmarest[1], Mireille Gadenne[2], Patrice Gadenne[1], Marc Nogues[1], Claude Naud[2].

[1] *Laboratoire de Magnétisme et d'Optique de Versailles, UMR CNRS 8634, Université de Versailles Saint-Quentin, 78 035 Versailles cedex, France.*

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Université Pierre et Marie Curie, 75 252 Paris cedex 05, France.

13:25

O26 Characterization of Amorphous Fe-Ni-B Magnetic Nanoparticles Synthesized by Chemical Route

D. Zysler[1], C. A. Ramos[1], H. Romero[2], A. Ortega[2]

[1] *Centro Atómico Bariloche and Instituto Balseiro, 8400 S. C. de Bariloche, RN, Argentina.*

[2] *Dpto. de Física, Fac. de Ciencias, Universidad de Los Andes, Mérida, Venezuela.*

13:40 CLOSING REMARKS

ABSTRACTS

(Abstracts are listed in order of presentation)

I1

Superparamagnetic Relaxation Modes And Inter-Particle Interactions In Samples Of Hematite Nanoparticles.

S. Mørup, F. Bødker and M.F. Hansen
Department of Physics, Technical University of Denmark, DK-2800 Lyngby, Denmark

Samples of hematite nanoparticles with average size between 7 and 20 nm have been prepared by chemical methods and studied by use of Mössbauer spectroscopy and magnetization measurements. Some of the particles were coated in order to minimize inter-particle interactions. Mössbauer spectroscopy showed that the sublattice magnetization directions are confined to the (111) plane at temperatures down to 5 K. Mössbauer spectra at higher temperatures thus give information about a two-dimensional superparamagnetic relaxation within this plane. Magnetization measurements give information about the fluctuations of the net magnetic moment of the particles, the main contribution of which arises from the small canting of the sublattices. Therefore magnetization measurements also give information about the fluctuations of the net magnetization vector out of the (111) plane. The coated samples exhibit a superparamagnetic behavior which seems to be in accordance with the Néel expression for the relaxation time: $\tau = \tau_0 \exp(KV/k_BT)$. It was found that τ_0 increases and K decreases with increasing particle size. Mössbauer studies of uncoated samples showed magnetic splitting at temperatures far above the blocking temperatures of the corresponding samples of coated particles. This shows that inter-particle interactions between the (canted) antiferromagnetic hematite particles are quite significant.

I2

Collective Dynamics in Dense Ferrofluids

Per Nordblad[a], Petra Jönsson[a], Mikkel Fougt Hansen[a,b], Peter Svedlindh[a]
[a] *Department of Materials Science, P.O. Box 534, Uppsala University, SE-751 21 Uppsala, Sweden*
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The dipolar interaction in dense ferrofluids introduces random and frustrated coupling between the particle moments and may even generate a low temperature spin glass phase. We have used low field dynamic susceptibility experiments, i.e. dc magnetic relaxation and ac susceptibility measurements, to study the magnetic response of some different ferrofluids in a time-window ranging over 10 decades in observation time (frequency). By comparing results from very dilute samples to the behaviour observed for dense samples of the same particle systems, it is possible to distinguish the effects of the interaction on the dynamic response. It is concluded that the low temperature dynamics of dense ferrofluids is constrained by the strongly temperature dependent relaxation times of the individual particles but controlled by collective spin glass like dynamics. Spin glass characteristics such as: a remarkable broadening of the response function at low temperatures and a chaotic non-equilibrium nature of the response function (ageing) are always observed and in certain systems even conventional critical slowing down indicating a low temperature spin glass phase has been established.

I3

Dynamics of γ–Fe_2O_3 Nanoparticle Systems

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[2] *Faculty of Physics, Alexandra Ioan Cuza University, Blv. Copou 11, Iasi 6600, Romania*
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[4] *LCMC, Université P. et M. Curie, 75252 Paris Cedex 05, France*
[5] *LMOV, CNRS, Université de Versailles, 78035 Versailles Cedex, France*

The dynamical properties of many series of samples of γ-Fe_2O_3 nanoparticles (5 to 10 nm in average diameter <f>) dispersed in a polymer were investigated by means of AC susceptibility measurements in a large frequency range (10-10000 Hz). The temperature and frequency dependence of both linear and non-linear susceptibilities were analysed for different concentrations of particles in the polymer, i.e. for different strengths of dipole-dipole interparticle interactions. Within each series, the initial susceptibility decreases with increasing interactions, in agreement with the results of Monte-Carlo simulations (1). For the most diluted samples, where interparticle interactions are negligible due to the large interparticle distance d ≈ 5 <f>, the dynamical susceptibilities are compared to the Raikher and Stepanov model (2) for the linear and non-linear (cubic) initial susceptibilities of an assembly of uniaxially anisotropic non-interacting fine particles. The experimental results for both linear and cubic susceptibilites are well described by the model. The values of the parameters of the particle size distribution and of the average energy barrier, deduced from the fitting, are in good agreement with other previous studies. The frequency dependence of the temperature of the maximum of the linear, in phase, susceptibility (T_{max}) is well described, for different strengths of interparticle interactions, by a superparamagnetic model accounting for interactions (3). On the other hand, for a powder sample a critical slowing down of the relaxation time, according to a power law, was found, like in spin glasses, indicating a collective dynamical behaviour. However, unlike in spin-glasses, the temperature dependence of the non linear susceptibility does not show any divergence approaching T_{max} .

1) R.W. Chantrell, G.N. Covedale, M. El Hilo and K.O'Grady, J. Mag. Mag. Mat. 157-158, 250(1996)
2) Y.L. Raikher and V. Stepanov, Phys. Rev. B 55, 15005 (1997)
3) J.L. Dormann, L. Bessais and D. Fiorani, J. Phys. C 21, 2015 (1988)

O1

Dynamical Properties of Non-Interacting Co Nanoparticles Embedded in a Polymer

M. Respaud,[a] J.M. Broto,[a] M. Goiran,[a] L. Thomas,[b] F. Lionti,[b] B. Barbara,[b] T. O. Ely,[c] C. Amiens,[c] B. Chaudret,[c]

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We present the study of the dynamical properties of an assembly of Co nanoparticles using high frequency ferromagnetic resonance (HFFMR), and ac susceptibility (χ_{ac}). The particles were synthesised using the decomposition of an organometallic precursor of Co in the presence of a polymer under dihydrogen. The steric stabilisation of the particles by the polymer allowed both the control of the size and the dispersion. We thus obtained a system of well isolated particles displaying a very narrow size distribution centred around 2nm diameter. Static magnetisation measurements show that the particles behaved as superparamagnets above the blocking temperature (T_B). Their basic characteristics are both an enhanced magnetic moment as in time of flight particles and an amplified anisotropy compare to the bulk values. These two features can be interpreted in term of surface effects. HFFMR have been performed at several frequencies (344 and 647 GHz) in the Faraday configuration using pulsed fields up to 35 T. The HFFMR spectra correspond to the sample transmission vs applied magnetic field. We used such configuration with high frequency and high fields in order to avoid any superparamagnetic behaviour, which induces a temperature and field dependence of the anisotropy field. If the gyromagnetic ratio was found in the same range than in bulk Co, the relaxation time (associated to the FMR effect) was found two times lower. Thus the damping parameter is around found to be 0.3 approximately two times above the bulk value. χ_{ac} measurements performed at several frequencies (f) followed classical superparamagnetic behaviours with an increase of T_B with f. We thus estimated the thermal dependence of the relaxation time. It was found to follow the classical Néel-Brown dynamics with a pre-exponential relaxation time $\tau_o = 4\ 10^{-12}$ s. By using the different experimental parameters determined by magnetisation and HFFMR measurements, we calculated the theoretical value according to the latest refined expressions obtained by Coffey et al. and found it in good agreement with the experimental one. We thus demonstrated for the first time that the theoretical models are able to predict the relaxation time.

[1] I. M. L. Billas et al. , Science, **265** (1994) 1682.
[2] M. Respaud et al., Phys. Rev. B **57** (1998) 2925.
[3] W.T. Coffey et al, J. Mag. Mag. Mat. **127** (1993) L254.

O2

Effect of Interparticle Interactions in $(Fe_{0.2}Ni_{0.8})_{100-y}B_y$ Magnetic Nanoparticles

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The magnetic properties of amorphous $(Fe_{0.2}Ni_{0.8})_{100-y}B_y$ nanoparticles (mean diameter ~15Å), synthesized by chemical route [1], have been investigated by magnetization measurements. In order to study the effect of interparticle interactions, the measurements were performed on two samples: the first consists of particles homogeneously dispersed in a polymer matrix, so diluted (2.5 %) that dipole-dipole interparticle interactions can be neglected; the second is a powder sample where strong interparticle interactions are expected. The diluted sample shows the characteristic behaviour of an assembly of independent nanosized particles, characterized by a narrow size distribution, with a sharp maximum of the low field zero field cooled magnetization (M_{ZFC}) at T_{max} = 60 K, whereas the field cooled magnetization (M_{FC}) increases continuously with decreasing temperature. On the other hand, for the powder sample M_{ZFC} shows a larger maximum centered at 100 K, the increase of T_{max} being due to interparticle interactions [2]. For the diluted sample, the hysteresis cycle at low temperature shows the regular hysteresis cycle for an assembly of non-interacting or weakly interacting particles in the blocked state. On the other hand, for the powder sample, below a certain temperature the virgin magnetization curve lies below the remagnetizing curve. This behaviour disappears approaching T_{max}. For the diluted sample, the high temperature magnetization curves are satisfactory fitted to a superposition of Langevin functions due to a volume distribution. On the other hand, the magnetization curves for the powder sample can be fitted to a Langevin function only if interparticle interactions are taken into account by introducing a mean field like term in the argument.

[1] R. D. Zysler, C. A. Ramos, H. Romero, A. Ortega, this issue.
[2] J. L. Dormann, D. Fiorani, E. Tronc, Adv. Chem Phys. 98 (1997) 283.

O3

Magnetic viscosity study of thin flexible RE Magnet-Foils

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A magnetic viscosity study of flexible thin foils containing rare-earth alloy-powders, $Sm_2(Co,Cu,Fe,Zr)_{17}$, has been performed in order to study the time-dependent effects of these new and technologically relevant materials. Isotropic magnetic foils, 200 μm thick, were manufactured by the solvent casting method(1). Magnetic viscosity, S, and irreversible susceptibility, χ_{irr}, were measured as a function of the magnetic field, at 10 and 300 K, and as a function of temperature, down to 1.8 K, at a field near the coercive field, by using an SQUID magnetometer. The temperature and field dependence of the fluctuation field, S_v, is deduced from the expresion $S_v=S/\chi_{irr}$ in order to evaluate the activation energy and the activation volumen(2). An investigation of the relationship between reversible and irreversible magnetization has been carried out. Results are evaluated in terms of a phenomenological model which takes M_{rev} as a function of M_{irr} and the internal field.

(1) Rodewald W., Wall B., Fernengel W.k Katter M. and Antochin S., Proc. 15th Int. Workshop on RE magnets and their applications, vol. I, Sao Paulo 1996, pp. 194.
(2) Givord D., Lienard A., Tenaud P. And Viadieu T., Journal of Magnetism and Magnetic Materials 1987, L281.

I4

Mesoscopic Quantum Coherence in Molecular Clusters

J. Tejada, J. M. Hernández, E. del Barco E. M. Chudnovsky
Fac. Física , Universitat Barcelona, Barcelona, SPAIN

J. Brooks and N.Biskup
Dept. of Physics, National High Magnetic Field Lab., Univ. of Florida, Tallahassee, Florida USA.

In this talk we will comment on the observation of coherent quantum oscillations of the spin of Fe_8 magnetic molecular clusters. The resonance experiments were done using a powder of magnetically oriented Fe_8 crystallites in the temperature range between 20 mK and 5K and for frequencies comprise between 680 MHz and 100 GHz. The resonance frequencies found experimentally are compared with those calculated using the Hamiltonian of the system ($\boldsymbol{H} = -DS_z^2 + CS_x^2 + g\mu_B \boldsymbol{H}\cdot\boldsymbol{S}$).

I5

Macroscopic Quantum Tunneling in Molecular Magnets

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Laboratoire de Magnétisme Louis Néel, CNRS, BP166, 38042 Grenoble, Cedex-09, France
[a] *Fakültat für Chemie, Universität Bielefeld, D-33501 Bielefeld, Germany*
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Our present understanding of the phenomenon of Quantum Tunneling of the Magnetization, is reviewed on the light of the experiments performed on big molecules with large spins (S=10, Mn_{12}-ac and Fe_8). Both single and many-molecule effects are considered (crystal field, hyperfine and dipolar interactions). Another big molecules (so-called V_{15}), but with a low spin (S=1/2), has been recently studied. The characteristics of big molecules with low spins will be described for the first time. The role of phonons is here essential.

L. Thomas et al, Nature 383 (1996) 145-7
B. Barbara and L. Gunther, Physics World, March 1999.
B.Barbara et al, invited review, issue 200 of JMMM (to appear).
I. Chiorescu et al, PRL, submitted.

I6

Molecular Magnetic Clusters

Dante Gatteschi and Roberta Sessoli
Department of Chemistry, University of Florence, Florence, Italy

Molecular clusters have been recently added to the zoo of nanomagnets. As compared to other types of particles they have the advantage of being absolutely monodisperse, with an accurately known structure. Further they are soluble in appropriate solvents and can be kept sufficiently separated one from the other to minimize the interparticle interactions. They provide unique opportunities for monitoring quantum size effects in nanomagnets. These range from stepped magnetisation, to anomalies in the nuclear relaxation rate. Particular attention has been devoted to the possibility of observing quantum tunnelling of the magnetisation at low temperature. Direct evidence for this has been achieved with Fe_8 below 300 mK, while indirect evidence has been obtained by controlling the longitudinal magnetic field in Mn_{12} and Fe_8, which provided a stepped magnetic hysteresis. More recently it has been possible to achieve evidence of topological interference effects associated to the Berry phase by controlling the transverse magnetic field. We will briefly review these properties of the magnetic molecular clusters and propose some general view for the mechanisms of tunnelling in nanomagnets.

O4

Secondary Relaxation Regimes in Mn_{12} Organic Cluster Compounds

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We present experimental evidences of secondary relaxation processes in oriented crystallites of Mn_{12} acetate and in a single crystal of Mn_{12} 2-Cl benzoate which are organic cluster compounds exhibiting quantum tunneling of the magnetization. Dynamical magnetic measurements indicate that for both samples the anisotropy energy barrier is approximately equal and that the relaxation times have sharp minima at the same resonant fields. However, we show that for both compounds approximately 1% of the clusters do not undergo this main relaxation process. From ac susceptibility experiments, we report evidence of a continuous distribution of faster relaxation times, giving rise to a second relaxation regime for these minority portions of the clusters. The zero-field effective relaxation times of such a distribution follow an Arrhenius law with energy barriers of 23 K and 30 K for the acetate and the benzoate, respectively. The effective relaxation times field dependence points toward the existence of quantum tunneling with $H_z = 0$ being a resonant field for both samples. In the case of the acetate, we compare these results with zero-field magnetization measurements.

O5

Field-Dependence of the Magnetic Relaxation in Mn12-Acetate

Yicheng Zhong, M.P. Sarachik
(City College of New York)

Daniel Ruiz, D.N. Hendrickson
(University of California, San Diego)

Enhanced magnetic relaxation rates in Mn12-acetate at specific values of the magnetic field have been attributed to quantum tunneling of magnetization(J. R. Friedman, M. P. Sarachik, J. Tejada, and R. Ziolo, Phys. Rev. Lett. 76, 3830 (1996).). We have performed a detailed study of these resonances in millimeter-sized single crystals of Mn12-acetate in magnetic fields up to 2 Tesla applied parallel to the easy axis of magnetization at temperatures between 1.7 and 2.6 K. Our data reveal fine structure as a function of magnetic field which is qualitatively different for odd and even numbered resonances. Measurements were also performed for a narrow range of longitudinal fields around the H=0 resonance in fixed transverse fields between 0 and 800 Oe. The relaxation rate remains roughly constant for externally applied transverse fields up to about 300 Oe. The relaxation increases dramatically for fields above 300 Oe, an increase which is reflected only within a narrow 100 Oe range about the center of the resonance. These results will be discussed in the light of our current understanding of tunneling in Mn12-acetate.

O6

Hall Magnetometry Studies of Molecular Magnet Fe_8 Single Crystals

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Molecular magnets, such as Fe_8 and Mn_{12}, have been intensively studied because they enable investigation of a mesoscopic magnetic system. It has been established that these clusters can be considered as model magnetic particles with spin S=10, which exhibit quantum tunneling of magnetization below a blocking temperature [1]. Fe_8 has a biaxial anisotropy, and in contrast to the uniaxial cluster Mn_{12}, has significantly higher tunnel splittings of low lying magnetic sublevels. This enables investigation of quantum coherence [2, 3], and generally quantum tunneling at low temperatures and small bias fields. We have studied the transition of the system from pure quantum to the thermally activated tunneling regime. Magnetic measurement on Fe_8 single crystals were performed using a micro-Hall effect magnetometers. Our technique is particularly suited for such experiments, since Hall magnetometers are highly sensitive linear devices, matched to the size of the studied crystals. These magnetometers permit measurements over a large range of magnetic field (up to 10 T) and temperature (0.3 K to room temperature). We will discuss results obtained on Fe_8 and contrast them to similar experiments on Mn_{12}.

This research is supported by NSF-INT Grant and NYU.

[1] C. Sangregorio, T. Ohm, C. Paulsen, R. Sessoli and D. Gatteschi, Phys. Rev. Lett. **78**, 4645 (1997)
[2] E. del Barco, N. Vernier, J.M. Hernandez, J. Tejada, E.M. Chudnovsky, E. Molins and G. Bellessa, xxx.lanl.gov/abs/cond-mat/9810261
[3] W. Wernsdorfer and R. Sessoli, Science **284**, 133 (1999)

I7

Magnetic Nanoparticles In Insulating Matrices

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David J. Smith and M. R. McCartney
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Composite films of magnetic nanoparticles (MNP) in insulating matrices can be used for a number of information storage applications at high densities and data rates. These include: GMR sensors for read-heads; high resistivity, high permeability films for write-heads; and storage media. We have prepared a number of different types of these composite structures by co-sputtering, or by successively sputtering, from magnetic (Co, CoFe) and insulating (SiO2, HfO2) targets. The volume fractions of the MNP and the insulators were controlled to produce samples ranging from non-interacting to percolated MNP. The samples included: (a) three-dimensional random assemblies of MNP, i.e., cermets; multilayers consisting of alternating insulating layers and monolayers of MNP; (c) spin-dependent tunnel junctions in which the magnetic electrodes were monolayers of MNP; and MNP monolayers. These samples were characterized by high resolution TEM, Lorentz microscopy, x-ray diffraction, magnetometry, magneto-transport, neutron diffraction, STM, and impedance measurements. Not surprisingly, these samples exhibited a rich variety of properties. This presentation will deal primarily with magnetic and magneto-transport behavior, including such issues GMR response, coulomb-gap evidence, magnetic versus structural correlation lengths, and the temperature dependence of these properties. The correlation of magnetic and magneto-transport behavior with structural information will be emphasized.

I8

Low Field Magnetoresistance in Fine Particles of $La_{0.67}Ca_{0.33}MnO_3$ Perovskites

J. Rivas[a], L.E. Hueso[a], A. Fondado[a], F. Rivadulla[b], and M.A. López-Quintela[b]
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Since the discover of intrinsic Colossal Magnetoresistance (CMR) around the magnetic phase transition in manganese mixed valence perovskites, a huge kind of extrinsic effects have appeared in these materials. One of the most important in the so-called Intergrain Magnetoresistance (IMR), related with the presence of grain boundaries in polycrystalline materials or films [1]. In this work we present electrical resistivity, magnetoresistance and magnetization results in well-characterized $La_{0.67}Ca_{0.33}MnO_3$ nanoparticles systems. Reducing grain size in polycrystalline samples down to the nanometric range we obtain new results that arise directly from the increasing grain surface contribution. We have employed a sol-gel technology with urea as gelling agent in order to obtain single-phase perovskites with grain size ranging from 60 nm to 500 nm [2]. We also prepared high temperature ceramic samples with grains bigger than 10 (m in order to compare our results, so we are able to change the grain size in three order of magnitude in order to explore a whole range of different behaviors. The crystallinity and the size and shape of the grains were checked by x-ray diffraction and scanning electron microscopy, respectively. Magnetization measurements show us that Curie temperature (TC) does not change with grain size although magnetization is being reduced as grain size does. At the same time, metal-insulator transition temperature (TM-I) decreases. This effect has been justified as a combination of intergranular resistivity and oxygen vacancies contribution. Meantime, a low temperature zone of activated resistivity appears in smaller grain samples, without any correspondence in the magnetic behavior. This is explained under a granular materials conductivity model that predicts the appearance of an additional electrostatic barrier between grains [3]. Magnetoresistance also feels affected by the change in grain size. Around TM-I, intrinsic colossal magnetoresistance is suppressed by reducing grain size. When grain are single magnetic domain, some theory predicts CMR destruction via disappear of domain walls. At lower temperatures, magnetoresistance response seems to follow a tunneling model for intergranular magnetoresistance, as can be fitted with square of magnetization and depends on grain size as 1/D, where D is the diameter of the grains. In summary, we present a great variety of extrinsic effects on the electric transport of $La_{0.67}Ca_{0.33}MnO$
fine particle samples.

[1] H.W. Hwang, S-W. Cheong, N.P. Ong, B. Batlogg, Phys. Rev. Lett. 77 (1996) 2041.
[2] C. Vázquez-Vázquez, M.C. Blanco, M.A. López-Quintela, R.D. Sánchez, J. Rivas, S.B. Oseroff, J. Mater. Chem. 8 (1998) 991.
[3] P. Sheng, B. Abeles, Y. Arie, Phys. Rev. Lett. 31 (1973) 44.

I9

Interplay of Spin Dependent Tunneling and Coulomb Blockade In Co Clusters Based Tunnel Junctions

J. Briatico, J. Carrey, V. Cros, J-L. Maurice, F. Petroff , A. Vaurès and A. Fert
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C. Vouille and G. Faini
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Tunneling of electrons between ferromagnetic electrodes separated by a thin insulating spacer depends on the relative orientation of the magnetizations in the electrodes. In an applied magnetic field, it generates tunnel magnetoresistance (TMR). Other interesting effects, namely the Coulomb blockade and staircase, appear when the size of a tunnel junction is reduced to the nanoscale. These phenomena are related to single electron quantum transport and magnetic memories could be ultimately based on single electron (spin) tunneling. We have investigated the interplay between spin tunneling, TMR and Coulomb blockade in double barrier magnetic tunnel junctions with intermediate stage on small (1-3 nm) Cobalt clusters in the tunneling processes. Experimental results have been obtained on macroscopic junctions (arrays of nano-junctions in parallel) and progress in the investigation of a single Co cluster by scanning tunneling spectroscopy and nano-fabricated point-contacts will be presented. The theory developed to account for the influence of the magnetic configuration on charging effects, the so-called magneto-Coulomb phenomena, will also be discussed.

I10

Domain Wall Scattering in Granular Thin Films

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Magnetoresistive rf-sputtered CoFe-Ag(Cu) granular thin films with ferromagnetic (FM) volume content, x_v, ranging from 0.30 to 0.45 (percolation threshold, x_p~0.5) were studied. At those concentrations a long-range domain magnetic microstructure with a net out-of-plane signal appears (magnetic percolation) as a consequence of the interplay between exchange and dipolar interactions and perpendicular uniaxial anisotropy. These magnetic domain structures are stripe-like and similar to those observed in hcp Co thin films and they have been observed by magnetic force microscopy. The existence of the domain structure is observed in the MR curves in spite of its small contribution [1] since the strong correlations reduces considerably the classical GMR effect. In addition, at these concentrations, very long relaxation times appears. This is due to the many different energy states available by connecting particles through different paths. Therefore, upon changing the applied field, the time needed to stabilize the minimum energy configuration becomes very long and the system present different remanent states as a function of the magnetic history. This is at the origin of the training effects observed in the MR loops, hysteresis loops and MFM pictures as described in Ref.[2]. The resistance and domain structures of the different remanent states have been correlated showing that larger domains, and consequently lower domain walls density, lead to smaller resistance values, evidencing the contribution of the domain walls to the overall resistivity of the sample. As annealing segregates and grow the CoFe particles and modify the crystal structure, the domain configuration is lost and the domain wall contribution to the resistivity is progressively removed.

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O7

Tunneling Magnetoresistance of Granular Films Made of Well-Defined Co Clusters Embedded in an Inert-Gas Matrix

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Granular films consisting of well-defined Co clusters embedded in an insulating inert-gas matrix (Kr, Xe) have been prepared by the co-deposition of in-beam prepared Co clusters and inert-gas atoms onto a cold substrate. Films with a Co volume fraction v_{Cl} below the percolation threshold $v_p \approx 34\%$ exhibit a negative magnetoresistance, the so called tunneling magnetoresistance (*TMR*). This can be explained in terms of tunneling of spin-polarized electrons between ferromagnetic grains with a magnetic field dependent orientation of their magnetic moment directions. The *TMR* therefore can give information on the spin polarization *P* of the conduction electrons at the Fermi energie E_F. In Julliere´s simple model *TMR* and spin polarization *P* are related by $TMR=P^2/(1+P^2)$ [1]. Our above described preparation method has some advantage in comparison to common ways of preparing granular *TMR*-samples: these usually are prepared by co-sputtering or co-evaporation of the two compounds onto a warm substrate or by reactive sputtering. The obtained samples naturally are not well-defined with respect to metal cluster size and insulating matrix, respectively. By the co-deposition of Co clusters, prepared with a so called gas-aggregation cluster source, together with inert-gas matrix atoms onto a cold substrate (T=40K) one has both well-defined clusters and a well-defined insulating matrix. Our films were evaporated onto a sapphire substrate that is mounted onto the coldfinger of a ^{4}He cryostat. The resistance of the films was measured *in-situ* by a dc-four-probe technique both as function of temperature and of external magnetic field ($B \leq 1.2$T). We compare two samples of Co clusters embedded in a Kr and Xe matrix, respectively. The resistivities at 20 K of the two samples differ by three orders of magnitude (Kr: $\rho = 1 \cdot 10^7 \mu\Omega$cm, Xe: $\rho = 4 \cdot 10^{10} \mu\Omega$cm). The $R(T)$-dependence of both samples confirm the theoretical predicted $R \propto exp(C/T^{1/2})$ - law for the tunneling resistance [2]. Despite of the big difference in the resistivity of the two films the *TMR* stays nearly the same (Kr: *TMR*(10K)=7.1%, Xe: *TMR*(16K)=6.2%). Therefore, our first experimental results indicate that the *TMR* essentially is independent of the tunneling barrier height or thickness, respectively, confirming Julliere´s simple model. Further experiments are in progress.

This work was supported by the Deutsche Forschungsgemeinschaft (SFB 341).

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I11

Magnetization reversal studied in single nanometer-sized particles and clusters

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This talk discuss the magnetic properties of nanometer-sized particles. The main questions are: How can we perform experiments on an individual particle? What is the influence of the measuring technique on the system of interest? How do the magnetic properties change with particle sizes and temperature? What is the particle size below which do quantum effects become dominant and how can they manifest themselves on the macroscopic scale? In order to answer these questions, we discuss briefly various measuring techniques and review the basic concepts of a new micro-SQUID technique which allows us to study single nanometer-sized magnetic particles at low temperature. In the case of sufficiently small particles, the magnetization reversal occurs by uniform rotation and the measurement of the angular dependence of the magnetization reversal yields the effective magnetic anisotropy. The influence of the temperature on the magnetization reversal is discussed. Probabilities of switching, switching field distributions, and telegraph noise measurements are proposed to check the predictions of the Néel Brown theory describing thermal activated magnetization reversal. At very low temperature, we will see how quantum effects can be revealed.

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I12

Disentangling Distribution Effects and Nature of the Dynamics in Relaxation Measurements: The RMR Method

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Even when they are small enough to be magnetic single-domains, magnetic nanoparticle samples are complex systems. The distributions of sizes and shapes yield a distribution of the anisotropy energy barriers driving the magnetization reversal. Because of the exponential dependence of reversal times upon the energy barrier heights, small distribution widths lead to relaxation times spanning several orders of magnitude. This has been shown to impede a simple comparison of experiments with the theoretical predictions for Quantum Tunneling of the Magnetization, which is expected to dominate over Thermal Activation (TA) at low enough temperatures. As a result, and in spite of their popularity, traditional "magnetic viscosity" measurements are not a good tool for evidencing QTM, because they are directly proportional to the energy barrier distribution, whose shape is unknown in the low energy-low temperature region of interest in this problem. We show how one can overcome this difficulty by using a modified viscosity measurement procedure, the "Residual Memory Ratio" (RMR): a temperature square-pulse is applied to the sample while measuring its magnetic relaxation rate. The observed variations of the relaxation rate are studied as a function of the plateau temperature reached during the pulse. We show numerically that this creates a strong contrast between TA and QTM behaviors, whatever the shape of the energy barrier distribution is. This method enables disentangling the nature of the dynamics from the distribution effects in size-distributed nanoparticle samples. We have measured various samples of ferrimagnetic particles (γ-Fe_2O_3 or $CoFe_2O_4$) and antiferromagnetic particles (horse-spleen ferritin), diluted in glass or ice to the lowest volume fractions (about 0.01%) allowed by our sensitivity. Most measurements have been made using a home made SQUID magnetometer coupled to a dilution refrigerator. The samples showed a RMR very consistent with a TA behavior for temperatures above a few Kelvin. When the temperature is decreased from a few K down to 100 milliKelvin or less, the RMR shows increasing deviations from TA. Those deviations cannot simply be explained by the effect of possible interactions between the particles, and they may support the occurrence of quantum tunneling events.

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[2] R. Sappey, E. Vincent, M. Ocio, J. Hammann, F. Chaput, J.P. Boilot and D. Zins, *Europhys. Lett.* **37**, 639 (1997)

I13

Evidence for a First Order Transition Between Quantum and Thermally Assisted Tunneling in a Molecular Magnet

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We have studied the transition from thermally assisted to pure quantum tunneling via temperature dependent magnetic hysteresis and relaxation experiments on single crystals of spin 10 molecular magnet Mn_{12}-acetate. It is now well established that magnetic relaxation in such materials is greatly enhanced at well-defined magnetic fields [1]. At relatively high temperature (T>1.6 K), the relaxation proceeds via thermal activation to discrete excited energy levels within a metastable magnetic well and tunneling across the anisotropy barrier. The levels from which most of this tunneling occurs, referred to as escape energy levels, change with temperature, with lower energy levels dominating as the temperature is reduced. Recent theory has suggested that the escape energy levels can change either abruptly or smoothly with temperature, and that the transition from thermally activated to pure quantum tunneling (i.e., tunneling from the lowest energy level in the metastable well) can be either first or second order [2]. We have conducted precise magnetic measurements on small single crystals of Mn_{12}-acetate using a micro-Hall magnetometer [3] in applied fields up to 8 T and at temperatures from 0.3 to 5 K. We discuss how magnetic measurements are used to accurately identify the escape energy levels both as a function of temperature and applied magnetic field. Results indicate an abrupt or first order transition occurs at a magnetic field dependent critical temperature for fields applied along the easy axis [4], consistent with theory [2]. General aspects of the theory and its application to spin 10 uniaxial nanomagnets will also be discussed.

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I14

Thermally Activated Magnetic Quantum Tunnelling at Zero Field in Magnetic Clusters and Small Particles.

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The recent discovery of thermally activated, field tuned, Magnetic Quantum Tunnelling in Mn12-Ac clusters has triggered a renewed interest in this fascinating effect, of basic and applied importance. This effect has been later observed in other magnetic clusters directly related to the Mn12-Ac, like the Mn12-2Cl benzoate and has opened the question whether this effect is quite general, not an exception in a very particular magnetic cluster. We report here our work on other systems, in particular on horse spleen ferritin. By means of magnetic ac susceptibility we have observed the presence of MQT at zero applied field as a minimum in the relaxation time, which increases for increasing field and has a maximum at H=3 kOe. It is also evidenced by the non-classical dependence of the blocking temperature of the superparamagnetic ferritin particles as a function of applied field. A comparison is drawn against classical theory for moment reversal.

O8

Non-adiabatic Landau-Zener transitions in low spin molecular magnet V_{15}

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The V_{15} polyoxovanadate complex belongs to the class of big molecules with very large Hilbert space dimension (2^{15}). It is made of 15 spins 1/2 with antiferromagnetic couplings and resultant S=1/2. Contrary to big molecules with large spins of the Mn_{12}-ac type, V_{15} has no energy barrier against $|1/2,-1/2> \leftrightarrow |1/2,1/2>$ spin rotation. Nevertheless, it presents a hysteresis with a constricted magnetic hysteresis loop. This phenomenon is due to the spins coupling with the environment leading to a non-equilibrium phonon density of states. The V_{15} molecular complex is a dissipative two-state system with field dependent energy separation of the levels, Δ_H. In zero field, hyperfine transverse fields create level repulsion of about 50mK, i.e. few orders of magnitude larger than in high spin molecular magnets (Mn_{12}, Fe_8). This has two consequences: (i) the occupancy of the ground state is not modified when reversing the field and (ii) the ratio Δ_H/k_BT is large enough to have phonons with energy Δ_H, which will authorize spin-phonon transitions between the two splitted levels. However, the phonon number is insufficient to thermalize the spin system and a hole burns in their density of states at Δ_H. This hole, moving with the sweeping field, leads to a non-equilibrium spin-phonon density, giving in the V_{15} complex the observed phonon bottleneck and constricted hysteresis. A "bottleneck plateau", identified on the measured hysteresis loop, gives a characteristic butterfly shape. These results are corroborated by the fit of relaxation experiments to this model.

O9

Phonon-Avalanches and Time Dependent Heat Capacity in Mn_{12} Clusters

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In this paper we discuss both theoretical and experimental results on the spin relaxation in a pulsed magnetic field and the time dependence of the heat capacity of oriented Mn_{12} crystallites when a magnetic field is applied parallel along the easy axes of the molecules. It is explained that: 1) the rapid switching of the magnetisation after the pulse magnetic field is applied is induced by spin-phonon avalanches combined thermally assisted resonant tunneling, and 2) the experimental values of the heat capacity for different temperature and time are well explained when considering that the heat capacity in these clusters is made of two contributions; the first one is associated to the thermal population of the S_Z levels in the two wells and the second one is due to transitions between the S_Z levels.

O10

Quantum Relaxation in the Magnetic Molecular Cluster Fe_8.

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In a perfect paramagnet the relaxation obeys the Debye-model and the relaxation curve is a single exponential. In the presence of disorder or interactions the relaxation behavior will change. To better fit the data, phenomelogical models include an additional parameter (in fact often two parameters). We report here new measurements of the ac susceptibility and dc magnetic relaxation as a function of temperature for Fe8 single crystals. At low temperature these molecular clusters behave like nanoscopic magnets each with a spin ground state of S=10 We use a dilution refrigerator to work at very low temperature (from 70 mK to 1.4 K) and a Dc SQUID to measure precise values of the magnetization. Below 0.4 K, Fe8 magnetic molecular clusters are in the pure quantum regime and relaxation occurs by quantum tunneling. Typical relaxation curves take 2 or 5 days and the data can be reasonable fit with a streched exponential. On the other hand, at higher temperature, the imaginary part of the ac susceptibility can be well fit with a lorentzian. We investigate the cross-over between these two regimes and the deviation from the Arrhenius law. Very unusual effects have been observed.

I15

Magnetic Particle Nanocomposite Refrigerants

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Nanocrystalline materials can possess bulk properties quite different from those commonly associated with conventional large-grained materials. Nanocomposites, a subset of nanocrystalline materials, in addition have been found to possess magnetic properties which are very sensitive to composition, a relatively easy variable to control. New magnetic phenomena, unusual property combinations, and both enhanced and diminished magnetic property values are just some of the changes observed in nanocrystalline matter from conventional magnetic materials. The magnetocaloric effect, upon which the technology of magnetic refrigeration depends, is one of these properties which may be enhanced in certain field and temperature regimes by finely dividing and grouping the magnetic species in a nonmagnetic or weakly magnetic matrix, as in a magnetic nanocomposite*. The basis for this enhancement will be reviewed and experimental data measured on several magnetic nanocomposites will be presented in proof of the earlier predictions of this effect. In addition, methods will be described which were developed in our laboratory for the fast screening of potential magnetic refrigerants. Included will be magnetocaloric effect data recently measured for a new chemically modified Dysprosium Aluminum Garnet (DAG) magnetic nanocomposite** which are larger than that for the presently used low temperature magnetic refrigerant GGG and related to that for the Gadolinium Gallium Iron Garnet (GGIG)*** magnetic nanocomposite. This new material also has potential applications at temperatures in excess of 20 K and at permanent magnet fields.

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I16

CoPt and FePt Granular Films for Magnetic Recording Media

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Future requirements for higher magnetic recording densities with low system noise impose the need for a medium consisting of magnetically isolated particles (grains) with a size below 10 nm and coercivity in the range of 3 - 5 kOe. This size approaches the superparamagnetic particle size of current information storage media and would lead to thermal effects and demagnetizing fields that tend to destabilize the magnetization of recorded bits. To avoid this, materials with higher anisotropy are required. Current studies are focused on CoPt(FePt) with $K \sim 5 \times 10^7$ erg/cm^3 and on rare earth intermetallic compounds with $K \geq 10^8$ erg/cm^3. In the former alloys, a structural phase transformation occurs below a certain temperature (825°C in CoPt and 1300°C in FePt) with the high temperature disordered fcc CoPt(FePt) phase transforming to the anisotropic fct phase at lower temperatures. We have recently prepared granular CoPt/M and FePt/M films with M = Ag, C, BN, SiO_2, consisting of CoPt(FePt) nanoparticles embedded in the matrix M, by co-sputtering from CoPt(FePt) and M targets using the tandem deposition mode. The as-made films have the disordered fcc structure, which is magnetically soft and have low coercivity. Magnetic hardening occurs after heat treating at temperatures in the range of 600 - 800°C, which leads to an increase in coercivity with values up to 15 kOe. Transmission electron microscope studies show fct CoPt(FePt) particles embedded in the M matrix with a size increasing from below 5 nm in the as-made state to 15 nm in the fully annealed state. These results are very promising and make these materials potential candidates for high-density magnetic recording media.

I17

Recent Developments in Metal Particle Technology for Flexible Recording Media

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In the next decade all high density flexible recording media will be based around metal particle technology. In this lecture the current status of MP systems will be reviewed from a technological and a commercial point of view. Subsequently, a detailed scientific evaluation of the current status of metal particles for high density information storage will be given in terms of the chemical composition, magnetisation reversal processes and the fundamental physical and chemical behaviour of the materials that determine their applicability. Principle amongst those items for consideration will be the crystallinity of the materials and its influence on the magnetic and other properties. Recent results will be presented on state-of-the-art systems sourced from the DOWA Company of Japan where a comparison of these development materials with commercially available pigments will be presented giving some indication of the direction in which the technology is proceeding.

I18

Room-Temperature Magnetoresistive Sensor Based on Thick Films Manganese Perovskite

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$La_{2/3}Sr_{1/3}MnO_3$ perovskite (LSMO), that show a ferromagnetic transition above room-temperature, is a good candidate to be used as a magnetoresistive sensor. Thick films prepared by screen printing technique is a well known method to develop low-cost sensors. Magnetic and transport properties of granular LSMO have been studied. And different grain size and the use of metal/insulator composites have been explored in order to optimize the low-field magnetoresistive response. We will also describe the preparation of screen printed LSMO thick films on polycrystalline Al_2O_3. The magnetoresistive response of the grown thick films are analyzed in the range of technical fields. It is shown, that under appropriate conditions, materials having field sensitivity high enough for some applications at room-temperature can be obtained. Steps towards integration of planar magnetic flux guiding components will be also reported. A magnetic sensor has been designed in order to show performance of this material to develop a low cost magnetic sensor.

I19

Alkali Metal Cation Effects in Hydrogel-Type Aqueous Ferrofluids for Color Printing

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Hydrogel-type aqueous ferrofluids of nanocrystalline maghemite are useful in the preparation of colored magnetic fluids because of their relatively low optical transparency and practical magnetic saturation moments. In the visible region, the optical properties of the nanocrystalline maghemite include an extinction coefficient nearly one order of magnitudelower than that of the bulk and a red shift in the absorption edge (1). To a first approximation, these observations were attributed to quantum confinement effects in the nanoparticulate. Other contributing effects, however, such as, vacancy ordering in the maghemite, gel-induced surface pressures and cation absorption by the maghemite, were not ruled out. Because of these possible contributing effects, the role of the alkali metal cation used in the preparation of the magnetic particles in the ferrofluids over the series Li, Na, K, Rb and Cs was examined. The results of this study will be discussed in terms of the preparation of the ferrofluids and their optical and magnetic properties.

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I21

Magnetotactic Bacteria

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Magnetotactic bacteria are an interesting topic, not only from the biological point of vue but from the magnetic one as well. These organisms are capable of synthetizing small single crystals of magnetite (Fe_3O_4), or maghemite (Fe_3S_4),. The magnetic particles have typical sizes ranging from 40 - 100 nm, just below the single domain critical size. Bacteria use these magnetosomes to form a chain of aproximately 20 particles which acts as a compass. We have performed magnetic measurements on lyofilized bacteria - that is as a dry powder made of aggregated bacteria - and, also, diluting the lyofilized bacteria in order to isolate individual cells which may behave as free particles.

I22

New Routes for the Preparation of Uniform Magnetic Particles

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This work is mainly concerned with the development of new methods of synthesis or new strategies of tailor-making materials with desired and controllable properties as an ultimate technological objective. In particular this paper is related to the preparation of magnetic iron oxides which have applications either as magnetic recording particulate media (ellipsoidal particles, 500-100 nm in length) or as magnetic sensors, catalysts, etc. (spherical particles, <10 nm in diameter). Uniform particles, in terms of composition, size and shape, are highly desirable for most of these material applications, as well as for fundamental research, which will provide the fast accessibility, high reliability and high capacity that magnetic devices request nowadays. Apart from the homogeneity of the samples and in order to get high density recording media, it is necessary to decrease the size of the magnetic particles and increase the coercivity obtaining a high signal/noise ratio. New synthesis routes of the precursor ellipsoidal particles, very uniform, with high axial ratio and lengths as small as 0.3 and 0.2 mm have been developed. A reduction in the reaction time together with an increase in the reaction yield have been attained by forced hydrolysis of an iron salt in the presence of urea, while a larger reduction in the particle size can be obtained by precipitation of iron sulphate with sodium carbonate. On the contrary, in the case of nanometer systems, materials with high magnetisation and low coercivity would be ideal for its application as a magnetic sensor and if the material is transparent it could also have important optical applications. Recent progress in the synthesis of magnetic nanoparticles both, in one single step by pyrolysis of aerosols and vapours, and directly in a silica matrix by sol-gel, are summarised in this work. It will be shown that the magnetic properties of nanoparticles are the result of contribution not only from both, size and interaction effects but also from structural internal disorder determined by the synthesis route. A special attention would be paid in this work to the infrared spectroscopy technique which has been shown as a powerful tool in the characterisation of nanoparticles. The results about structural order-disorder obtained from the IR spectra were endorsed by the magnetic behaviour exhibited by the materials.

O11

Bimetallic Nanoscale Magnetic Particles In Organic Matrices

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Well dispersed nanoscale particles (Pt, Co, Ni, Cu, Ag and binary alloys) have been obtained from the decomposition of organometallic precursors in the presence of an organic polymer which insures both chemical and physical stability to the dispersion. The size dispersity is low (+/- 0.3nm) and the mean size can be varied by adjusting the reaction conditions (metal loading, nature of the polymer ...)[1]. We will focuse here on magnetic materials. By this method clean, size controlled nickel particles of roughly 6nm were prepared at room temperature in polyvinylpyrrolidone from $Ni(COD)_2$ under H_2. Studies on these particles include HRTEM experiments for the determination of the structure and mean size, chemical adsorption to check surface cleanliness, and magnetic measurements. We further showed that the particle arrangement in the samples could be varied according to the experimental conditions which lead to different magnetic behaviors. We also prepared cobalt particles of 1nm or 1.5nm diameter in polyvinylpyrrolidone and 5nm in polydimethylphenyleneoxide from $Co(\eta^3C_8H_{13})(\eta^4C_8H_{12})$ under H_2. Magnetic measurements show that these particles have properties similar to those of cobalt particles studied in time of flight experiments, with enhanced magnetic moment per cobalt atoms which is characteristic of very clean surfaces without any strong interaction with the organic matrice[2]. In order to enhance the magnetic anisotropy of such systems we prepared alloyed cobalt platinum particles (d~1.5nm) by simultaneous decomposition of the cobalt ($Co(\eta^3C_8H_{13})(\eta^4C_8H_{12})$) and platinum ($Pt(dba)_2$; dba : dibenzylideneacetone) precursors in the conditions described hereabove. Structural and magnetic charaterization of three different alloys (compositions Pt3Co1, Pt1Co1, Pt1Co3) will be discussed.

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O12

Structural evolution of Co clusters in $Co_{15}Cu_{85}$ granular alloys by EXAFS spectroscopy

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Metastable $Co_{15}Cu_{85}$ alloys produced by melt-spinning have been annealed at increasing temperatures (T_a= 400, 450, 500, 550, 600, 650^{o}C) in order to study the evolution of the Co clusters and its relation with magnetic and magnetoresistance properties. A maximum value of 4% in the magnetoresistance at room temperature is found after annealing at 550^{o}C. EXAFS measurements on Co and Cu K-edges has been performed in the 7.1 station at the Daresbury Laboratory and in the GILDA line at the ESRF. EXAFS is a very sensitive technique to study the short range order and has allowed us to follow the apperance and evolution of the Co clusters in the CoCu matrix as a function of T_a. We have found that when increasing T_a, the Co-Co pair distance decreases while Cu-Cu increases, corresponding with an increase of Co clusters size. These variations are small for annealing temperatures below 550 ^{o}C, but increase strongly at higher temperatures. After annealing at 650 ^{o}C, both Co-Co and Cu-Cu interatomic distances correspond to the ones of pure fcc-Co and fcc-Cu phases respectively. Magnetic measurements also reflect this evolution in cluster size. A transition from an almost superparamagnetic to a ferromagnetic behavior is detected with increasing annealing temperature.

O13

Grazing-incidence x-ray measurements of granular recording media

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At present there is much interest in the effects of crystallographic defects in granular thin film magnetic recording media and their role in determining media noise and thermal loss of recorded signal. Stacking faults are common in thin film media, which can contain as much as 10% of the Co grains in the non-ideal hcp phase. Accurate quantification of the percentage of stacking faults in thin film media is not trivial thus synchrotron radiation is employed with a grazing incidence geometry (GIXS) to eliminate the large background scatter from the underlayers and amorphous substrate [1]. We have used the new UK beamline at the European Synchrotron Research Facility (ESRF) in Grenoble, France to characterising the stacking faults on a set of samples provided by Seagate Magnetics (Fremont, CA) which had been produced at different sputtering pressures. Earlier qualitative HRTEM measurements had already provided evidence of increasing stacking fault density with increasing sputtering pressure [2]. This has been confirmed by the increased intensity of the scatter at the position of the fcc (200) reflection. A quantitative measure of the stacking fault density has been obtained by careful fitting of the x-ray data. The overall aim is to correlate the results of existing magnetic viscosity measurements [2] with the obtained percentage of stacking faults. In addition, we have been studying the orientation of the c-axis of the hcp Co in and out of the plane of the sample and have found a marked difference between samples grown in high and low sputtering pressures.

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I23

Computational Studies of the Susceptibility of Interacting Fine Particles Systems

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The properties of magnetic fine particle systems are strongly dependent on the effects of intergranular interactions. In particular the effects of interactions on the low field susceptibility have been extensively studied because of the analogy with spin behaviour. The archetypal example is the observation of a peak in the low-field susceptibility. In a fine particle system this arises from a transition for superparamagnetic to thermally stable behaviour as the temperature is lowered. We have developed a Monte-Carlo model of the properties of a system of interacting particles, which simulates the time and temperature dependence of the magnetic properties. The model gives good qualitative agreement with experiment, for example in the prediction of an increase in the temperature of the susceptibility peak with packing density. The model also predicts a peak in the Field Cooled magnetisation arising from the effects of interactions. These obervations can be interpreted in terms of a slow transition to a state with short-ranged magnetic order at low temperatures. There is, however, no associated divergence of the magnetic correlation length and consequently no phase transition. The results are such that an interpretation in terms of a simple change in the energy barrier due to interactions is not possible

I24

The Microstructure and Magnetisation Processes in Nanocrystalline Systems

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Micromagnetic calculations based on computational methods are a pre-requisite to treat complex magnetisation processes in small particles or ensembles of grains. Applying the finite element method the spin structures and critical fields of small particles, thin platelets and ensembles of grains are determined by means of three-dimensional computational micromagnetism. It is shown that spin structures and magnetisation processes depend sensitively on the interplay between particle dimensions, microstructures and the three characteristic exchange lengths of the dipolar energy, $l_S = (2A/\mu_0 M_S^2)^{1/2}$, of the magnetocrystalline energy, $l_K = (A/K_1)^{1/2}$, and of the magnetostatic energy $(2A/\mu_0 H_{ex} M_S)^{1/2}$ (A = exchange constant, K_1 = anisotropy constant, M_S = spontaneous magnetisation). The differences between soft and hard magnetic materials which are governed by $l_S << l_K$ and $l_S >> l_K$, respectively, are discussed for examples relevant for permanent magnets, recording media and the sensor technique. In particular, the stability boundaries of single domain particles and multi-domain states as well as their intrinsic coercive fields for the reversal of magnetisation have been determined. It is found that the coercive field obeys an universal relation $\mu_0 H_C = \alpha (K_1 / M_S) \pm N_{\text{eff}} \mu_0 M_S$, where α and N_{eff} correspond to parameters which describe the modifications of the ideal nucleation fields due to the microstructure. For soft magnetic materials the (+)-sign holds and the last term dominates whereas for hard magnetic materials the first term dominates and in general the (−)-sign holds. For the case of nanocrystalline intermetallic compounds and for thin films the parameters α and N_{eff} will be discussed. Whereas for static problems the magnetic states may be determined from the minimum of the magnetic Gibbs free energy, for high field rates the Gilbert equations with a damping term $\dot{\alpha} M \times \dot{M}$ have to be solved. It turns out that the static coercive fields correspond to an upper limit. Taking care of the damping term and the precession of the magnetisation the dynamic coercive field is found to be smaller than the ideal coercive field, which becomes important for high field rates as in the case of magnetic recording.

I25

Simulation of Thermally Activated Switching in Fine Particles

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Micromagnetics at finite temperatures is of vital importance for high density magnetic storage. Thermally activated magnetization reversal becomes crucial for high speed switching and the thermal stability of written bits. The straight forward extension of standard numerical micromagnetics to treat thermally activated processes leads to the Langevin equation. This equation was applied to study the relaxation behavior of isolated and magnetostatically interacting particles. A precise formulation of Langevin dynamics within the framework of a continuum theory is required, in order to investigate nonuniform reversal modes of a single particle. This works presents a systematic study of the numerical solution of the corresponding stochastic partial differential equation. The interpretation of the Langevin equation in the sense of Stratonovich requires to apply special numerical schemes for time integration. The numerical results can be verified by comparing the stationary properties with the solution of the corresponding Fokker-Planck equation for a single magnetic moment subject to uniaxial anisotropy K. For the stochastic Euler and Milstein scheme the numerical error shows a minimum at a time step of $0.3\ J_s/(\alpha\gamma K)$, where J_s, α, and γ are the spontaneous polarization, the Gilbert damping constant, and the gyromagnetic ratio, respectively. The optimal time step can be increased by a factor of 10 using the Heun method. In the discretized equations the noise term scales with the square root of the time step. Thus the noise term exceeds the deterministic part for small time steps which will cancel any deterministic motion. A lower limit for the step was found to be $\Delta t = 0.03\ J_s/(\alpha\gamma K)$. The spatial discretization imposes a limit on the maximum time step. Either the finite difference or the finite element method can be used to discretize the partial differential equation in space. Stability analysis of the deterministic equation imposes an upper limit on the time step which is proportional to the square of the finite element size Δh. Large fluctuation fields create large gradients and lead to numerical instabilities and thus the time step must be smaller for higher temperatures. With a proper choice of Δt, the stationary properties can be shown to be independent of the mesh size. The algorithm was applied to calculate transitions between equilibrium states in cubic NiFe particles.

I26

Hysteresis and avalanches in frustrated and disordered systems

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We study time independent hysteresis in magnetic systems driven by an external field for which the influence of thermal fluctuations is negligible. In such systems the hysteresis cycles are not continuous but rather composed of a sequence of magnetization jumps or avalanches between metastable states: this is the so-called Barkhaussen noise. The study of the statistical distribution of such avalanches provides an alternative description to the more common procedure of measuring properties of the loop shapes. This method allows to obtain relevant information that may enable to classify different systems into the same universality class. We consider different zero-temperature (absence of thermal fluctuations) lattice models (1,2) like the Random Field, Random Bond, or Site Diluted Ising models (RFIM, RBIM, SDIM) by defining appropriate local dynamics for the study of the metastable evolution. We perform an analysis of the avalanche distribution as a function of the degree of disorder in these systems. The distributions exhibit critical behaviour and, thus, can be characterized by universal exponents.As a particular example we present a comparison of recent experimental results of the hysteresis of the spin-glass Cu-Al-Mn alloy system (3) with a realistic site diluted Ising model.

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I27

Asymptotic Formula for the Neel Relaxation Time Valid for all Values of the Damping Parameter.

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It is shown how the Mel'nikov Meshkov treatment of the Kramers escape rate theory which has been formulated for material particles may be easily extended to spins yielding a formula for the superparamagnetic relaxation time which is valid for all values of the damping parameter in the Landau-Lifchitz-Gilbert equation.

O14

Magnetic history dependence of metastable states in systems with dipolar interactions

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We present the results of a Monte Carlo simulation of the ground state and magnetic relaxation of a model of a thin film consisting on a two-dimensional square lattice of Heisenberg spins with perpendicular anisotropy K, exchange J and long-range dipolar interactions g. We have studied the ground state configurations of this system for a wide range of the interaction parameters J/g, K/g by means of the simulated annealing procedure, showing that the model is able to reproduce the different magnetic configurations found in real samples. We have found the existence of a certain range of K/g, J/g values for which in-plane and out-of-plane configurations are quasi-degenerated in energy. We show when a system in this region of parameters is perturbed by an external force that is subsequently removed different kinds of ordering may be induced depending on how the followed procedure. In particular, simulations of relaxations from saturation under an a.c. demagnetizing field or in zero field are in qualitative agreement with recent experiments on epitaxial and granular alloy thin films, which show a wide variety of magnetic patterns depending on their magnetic history.

O15

Micromagnetic modelization of thermal magnetization decay for interacting systems.

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The modelization of thermal magnetization decay in magnetic recording media is usually carried out in the approximation of non-interacting subsystems (see, e.g. [1]). However, the magnetostatic and the, usually weak, intergranular exchange interactions are unavoidably present in these materials and largely influence their hysteretic behavior. In this respect, the dynamic Landau-Lifshitz equation with a random contribution to the total effective field representing the temperature fluctuations can account for the occurrence of magnetic interactions. Unfortunately, this approach is not computer affordable due to the fact that the longer time for which the integration of the equation can be accurately performed hardly exceeds a few hundreds of ns. In this work we use a hybrid Landau-Lifshitz-Monte Carlo method with a term representing the temperature fluctuations which is calculated from the Brownian dynamics approach (and therefore proportional to $(T\ Dt)^{1/2}$, where T is the temperature and Dt the integration time step). An adaptive use of our hybrid method has allowed us to follow the relaxation process with an explicit time step which is from 10^3 up to 10^5 times longer than that usually considered when integrating the Landau-Lifshitz equation. Thus the total time range covered in our simulations can be of the order of 1s. The method is illustrated through the simulation of the thermal decay of longitudinally recorded bit patterns in a 3D random system (with both easy axis and grain volume realistic distributions) Conclusions about the dependence on the system parameters of the thermal stability limits are drawn from the simulation.

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O16

Monte Carlo Investigation of Magnetic Properties in Fe/Tb Multilayers

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Fe/Tb multilayers with small layer-thicknesses which exhibit large perpendicular magnetic anisotropy have potential application as high density magneto-optical recording media. In this study, we investigate, by Monte Carlo simulations, the layer-thickness dependence of the transition and compensation temperatures of amorphous Fe/Tb multilayers. Our model consists of a simple cubic A/B bilayer made up of pure A-planes (Fe layer), pure B-planes (Tb layer) and few mixed planes (between 0 and 4) of the $A_{1-x}B_x$ type representing the disordered interfaces. Each site of the bilayer is occupied by a classical Heisenberg spin of modulus S_A or S_B and the interactions are limited to the nearest neighbours. The interactions $J_{AA}(x) > 0$ and $J_{AB}(x) < 0$ have been estimated by preliminary simulations on a L×L×L simple cubic lattice on which A and B atoms are randomly distributed. The values which have been choosen are those which produce a specific heat peak at the Curie temperature of the amorphous alloy $Fe_{1-x}Tb_x$ and also a compensation point at the experimental compensation temperature. The minor interaction $J_{BB} > 0$ has been kept constant. As a first approach, we studied a bilayer with abrupt interfaces (0 mixed plane). Our results indicate that the transition temperature, T_C, increases as the A-thickness, t_A, increases which is inconsistent with experimental results. This disagreement is attributed to the existence of disordered interfaces which we did not take into account here. Then, we have considered disordered interfaces made up of either two atomic planes of the $A_{0.5}B_{0.5}$ type or four atomic planes of the $A_{0.8}B_{0.2}$, $A_{0.7}B_{0.3}$, $A_{0.3}B_{0.7}$ and $A_{0.2}B_{0.8}$ types. In both cases, we obtained a decrease of T_C as t_A increases in qualitative agreement with the experimental dependence. Since the transition is driven by the disordered interfaces, this decrease is explained by the diminution of the correlations between the disordered interfaces as t_A increases. However, the B-sublattice magnetisation dominates for all temperatures and all values of t_A in contradiction with experimental results. Actually, the "effective" Tb-magnetic moment in amorphous layers ($\approx 6\mu_B$) is significantly lower than the value of the free ion ($9\mu_B$) that we had firstly considered. Then, with $m_B = 6\mu_B$, we have been able to reproduce the experimental thermal behaviour of each sublattice magnetisation (just below T_C, the A-sublattice magnetisation is larger than the B-sublattice magnetisation). A compensation point has been observed for a thickness range which is in good agreement with the experimental one.

I20

Dipolar Interactions Induced Order in Assemblies of Magnetic Particles

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We analyze the formation of ordered structures in colloidal suspensions of magnetic particles. To this purpose, we focus on two representative cases. In the first problem we analyze aggregation phenomena of particles in 2D and 3D. At low temperature we observe clusters with a less branched and more open structure than free DLA. Their internal structures show a smooth transition between an ordered state at low temperature, with long-range correlations between dipoles, and a disordered state at high temperature, in which all relative orientations are equally probable. In the second problem we present a model of sequential adsorption of particles on a surface in which the adsorbing particles experience anisotropic dipolar interactions. These long-range interactions induce high ordered structures in the adsorbed layer. The order manifests through significant variation in the packing.

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I28

Adsorption and Surface Properties of γ–Fe_2O_3 Nanoparticles

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Samples of 3–10 nm γ–Fe_2O_3 particles with different surface chemical states, (i) hydrated, (ii) hydroxylated, and (iii) modified by phosphate adsorption, were obtained [1] from aqueous sols of well-dispersed γ–Fe_2O_3 particles, in the form of dispersions in a polymer in case (i) and powders in cases (ii,iii). The materials were characterized by chemical analysis, IR spectroscopy, X-ray diffraction and Mössbauer spectroscopy (4.2–300 K). Static magnetic properties were studied by magnetisation measurements (5–300 K, 0–5.5 T) and Mössbauer experiments (0–6 T). Three types of magnetic behaviour are observed. The hydroxylated particles (ii) show classical effects of unsaturated moment consistent with surface spin canting. The phosphate-coated particles (iii) behave like a two-phase system. All iron ions contained in the outermost O–Fe–O layer are bonded to phosphato groups. They are paramagnetic down to ca 30 K and order into a disordered magnetic state that is only weakly coupled to the γ–Fe_2O_3 core. The hydrated particles (i) show an unusual increase of the magnetisation with applied field at low temperature, below ca 100 K. Spin canting effects also appear below ca 100 K, and increase with decreasing temperature. The results, including particle size effects, suggest that the surface spins order at ca 100 K into a disordered magnetic state that seems strongly coupled to the core. The observed phenomena vary with the particle concentration in the matrix, but it has not yet been elucidated if this is related to varying interparticle interactions or to uncontrolled chemical and/or topological surface features. By analysing the data with a core/shell model, the intrinsic magnetisation of the core was determined and found independent of the concentration (interactions), as expected. The results are to be related to studies of dynamic [2] and static [3] properties of similar materials.

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I29

Surface-related effects on the magnetic properties of γ-Fe_2O_3 nanoparticles

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Magnetic nanoparticles are a subject of intense research due to their unique magnetic properties. When reducing particle size magnetic particles become single domain in contrast with the usual multidomain structure of the bulk materials and exhibit unique phenomena such as superparamagnetism, quantum tunneling of the magnetization , unusual large coercivities and considerable reduction of the saturation magnetization. The study of some of this issues has been carried out in γ-Fe_2O_3 nanoparticles with a very large surface to volume ratio. Platelet-shaped particle with mean sizes of about 9-10 nm exhibit strong exchange anisotropy and magnetic training effect, as well as high field irreversibility and large coercive fields. This behavior is correlated with the existence of a spin glass-like surface layer that becomes frozen below a well-defined temperature T_F of about 42 K.

I30

Surface Effects in Nanoparticles

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We present a microscopic model for nanoparticles and perform Monte Carlo simulations of their magnetic properties. On account of Mössbauer spectroscopy and high-field magnetization results, we consider a particle as containing a ferrimagnetically ordered core and a relatively disordered surface. The magnetic state in the particle is described by the anisotropic classical Dirac-Heisenberg model including exchange and dipolar interactions and bulk and surface anisotropy. We consider the case of ellipsoidal (or spherical) particles with open boundary conditions at the surface. Using a surface shell of constant thickness we vary the particle size and study the effects of surface disorder on the thermal and spatial behaviours of the net magnetization of the particle. We study the shift in the surface critical region for different values of the parameters. The spatial distribution of the magnetization is obtained and it is shown that the profile of the local magnetization exhibits strong temperature dependence.

I31

Thermal Dependence Of Coercivity In Co-based Nanostructures.

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In this work results on the thermal dependence of the coercivity at low temperatures of two intrinsically different Co-based systems are presented. The two studied systems are a series of Ni/Co multilayers and CoB melt spun ribbons. The multilayers, consisting of 10 bilayers each and with typical Co and Ni layers thickness around 100 Å were grown by sputtering. The melt spun CoB amorphous ribbons were submitted to successive thermal treatments in order to achieve a nanostructure consisting of Co grains (about 300 Å in diameter) embedded in an amorphous CoB matrix. Despite of the different compositional and structural features, both samples show a similar qualitative coercive field behavior. As the temperature decreases it is possible to divide the thermal dependence of Hc into two different regimes. For temperatures between 300 and 200 K the coercive field shows a slight growth, possibly associated to a reduction of the thermal activation, whereas for temperatures below 200 K Hc undergoes a sharp increase of almost one order of magnitude in both samples. These results are analyzed in the framework of a previously proposed model [1] which accounts for the coercivity in two phase systems consisting of a hard and a soft phase (cobalt and nickel or amorphous matrix respectively). It is proposed that the nature of the interface between the hard and the soft phase, through which the exchange coupling takes place, plays a main role in the magnetization process. This interface would become frozen below 200 K and would as well block the magnetization of the soft phase, thus giving rise to a hardening of the material. Above this temperature the interface would be unlocked allowing the soft phase to freely follow the magnetizing field. There is also a third regime above the Curie temperature of the soft phase in which the material suffers a new hardening due to the impossibility of the soft phase, now paramagnetic, to transmit the exchange coupling among the hard phases.

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I32

Ferromagnetic Resonance Studies of Multiphase Ferromagnets

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The theory of ferromagnetic resonance (FMR) and spin wave resonance (SWR) is presented for the general case of multiphase ferromagnets. We discuss the application of the theory to nanocrystalline materials, where nanometre size ferromagnetic crystals are embedded in an amorphous ferromagnetic phase which has a different magnetization. The theory is also applicable to systems where the amorphous phase is surrounded by a non-magnetic material. The possible existence of spin wave modes is taken explicitly into account for the first time in mixed phases, where the possibility of interface localised modes is also considered. The magnetic evolution of the nanocrystalline and amorphous phases in $Fe_{87}Zr_6B_6Cu_1$ glasses has beenstudied by FMR using the above theory. Resonance lines from the alpha-Fe nanocrystals, the surrounding amorphous phase and a disordered Fe-rich interface are observed and interpreted. At higher annealing temperatures further resonance lines appear as FeZr and FeB hard magnetic phases precipitate from the amorphous matrix.

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I33

Magnetic Behavior, Domain Dynamics and Microstructure in the $Fe_{13.1}Nd_xB$ Fine-Particle System

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We have studied the magnetic behavior of a range of $Fe_{13.1}Nd_xB$ ($2 < x < 147$) alloys as a function of the Nd content and annealing temperature (400-700°C) and characterized them by a wide range of measurements including x-ray diffraction, differential scanning calorimetry, thermogravimetric analysis and electron microscopy. These annealed samples show a systematic increase in room-temperature coercivity with Nd content, culminating in the largest value (~2.8T) ever reported in the Fe-Nd-B system when x ~ 147. Energy-filtered images, using spatially resolved measurements of inner-shell ionization edges, was critical in evaluating the particle shapes (platelets with the crystallographic c-axis normal to the plate), size (~100 x 40 x 25 nm) and distribution. For such randomly oriented, non-interacting particles, the largest observed coercivity, Hc ~ 2.8 T is ~90% of the theoretical limit expected for Stoner-Wohlfarth coherent rotation behavior including demagnetization effects. Initial magnetization curves and a systematic series of minor loop measurements show that the coercivity mechanism changes from the pinning-type at low Nd content, to the nucleation-type at higher Nd concentrations. In addition, the samples show a low-temperature spin reorientation and a peak in coercivity as a function of temperature. Understanding these results requires a systematic evaluation of the physical microstructure and the distribution of magnetic spins at the appropriate length-scale. Towards this end, high-resolution electron microscopy, Lorentz imaging of domain structures and micromagnetic modeling results will be presented.

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I34

Magnetism and Structural Features of Glass Coated Cu-based (Co,Fe,Ni-Cu) Microwires.

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Granular systems based on inmiscible Co-Cu and Co-Pt alloys have been intensively studied owing to their potential technological applications. Inmiscible alloys exhibit outstanding magnetic properties such as GMR and enhanced magnetic hardness with important technological applications [1]. These systems are generally obtained by the mechanical alloying, sputtering and rapidly solidification techniques. The samples obtained by these techniques have different shapes and geometry: thin films, powder, multilayers, and ribbons. Recently the Taylor Ulitovski technique has been widely employed to obtain magnetic materials as tiny fibres. Such tiny wire (microwire) consists on metallic nucleus and isolating glass coating. The glass coating introduces strong and complex internal stresses, which affect dramatically the magnetic and magnetoelastic behaviour. In addition, Co- and Fe-based microwires show outstanding magnetic properties such as magnetic bistability, GMI effect, enhanced magnetic softness, Matteucci effect etc and haven been intensively studied last few years [2]. The present work is dealing with the magnetic behaviour glass coated microwires. Different compositions Co_x-Cu_{100-x} ($10<x<90$), $Fe_{100-x}Cu_x$ ($30<x<50$), $Co_{29}Ni_{25}Cu_{45}Mn_1$ with different geometry (metallic nucleus diameter, d, from 3 to 10 μm and total diameter, D, from 15 to 25 μm) have been investigated. Different experiment techniques such as X-ray diffraction (XRD), VSM magnetometry have been employed in as-prepared and heat treated samples. XRD analysis evidences a certain correlation between grain size, geometry and coercivity which could be ascribed to the effect of internal stresses on grain size, A significant changes of the magnetization curves are observed in $Fe_{30}Cu_{70}$ samples depending on the ferromagnetic phase volume due to exchange interaction between the grains. Enhanced magnetic hardness (up to 750 Oe) has been obtained after annealing at 700 ^oC for 1 hour of $Co_{29}Ni_{25}Cu_{45}Mn_1$ microwires. It could be correlated with phase separation detected by the XRD. Magnetoresistance has been measured in Co-Cu microwires.

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I35

On The Hysteresis And Relaxation Of Hard-Soft Nanocomposite Samples

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We have prepared, by using a high-energy ball mill, a series of composite samples consisting of 99.99% Fe (45 □m average particle size) and $BaO6Fe_2O_3$ nanoparticles (platelets having an average size of 53 ± 8 nm). The different samples had a Fe volume fraction, x, ranging from 0.1 up to 0.9 and were milled during times from 15 up to 120 minutes. TEM imaging of the samples having the largest Fe contents showed that, upon milling, the $BaO6Fe_2O_3$ nanoparticles were fully embedded into the larger Fe particles. X-ray diffraction patterns taken in all the as-prepared samples did not show either $BaO6Fe_2O_3$ reflections or Fe oxide ones. The study of the magnetic properties was carried out by means of VSM and SQUID magnetometers covering a temperature range from 4.2 up to 300 K and a range of applied fields of up to 5 T. Our more remarkable results include, i) the observation, in loops measured by applying a maximum field of 0.8 T, of a loop shift having a magnitude comparable to the coercivity and increasing with the decrease of the milling time (that shift disappeared when the applied maximum field was increased up to 5 T), ii) a compositional dependence of the loop shift exhibiting two close to symmetric maxima at x = 0.25 and x = 0.75 and a minimum at x = 0.50, iii) different isothermal and demagnetization remanence values, measured after applying a maximum field of 0.8 T (the difference between both remanences increased with the Fe volume fraction), iv) a non-monotic relaxation behaviour at the demagnetization remanence corresponding to the application of a demagnetising field of the order of the coercive force. We discuss these data on the framework of the dipolar coupling between the phases present in the samples. Two different approaches are considered in that respect. The first one focus on the local dipolar fields associated to the anisometric $BaO6Fe_2O_3$ particles and the second one discusses the fluctuations of the average dipolar field associated to the fluctuations of the spatial distribution of particles.

I36

TEM Observations of the Response of Small Magnetic Elements to an Applied Field

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We are carrying out extensive studies of magnetisation processes in micron and sub-micron sized magnetic elements using transmission electron microscopy. The elements are fabricated directly onto thin electron-transparent substrates using electron beam lithography together with lift-off and reactive ion etching techniques. Our microscope, a highly modified Philips CM20 FEG has additional lenses so that the specimen can be imaged in field-free space or in a field of the experimenter's choosing. In this way we can carry out in-situ magnetising experiments in real time. Specimens of interest include single layer permalloy and Co films, spin-valves, spin tunnel junctions and Co/Cu multilayers. For single layer films we have studied the dependence of the switching mechanism and the field at which reversal occurs on the width and end-shape of the element. The latter is particularly important in that residual end-domain structures can be largely avoided if elements with pointed or sufficiently curved end shapes are fabricated. Other features that can be used to tailor switching fields are the introduction of structured edges which can act as wall traps. Switching fields are also strongly influenced by the magnetic state of near neighbour elements if tightly packed arrays are of interest. By studying the detailed reversal of the array as a whole, estimates of the strength of such magnetostatic interactions can readily be made. For elements fabricated from multilayer films, the behaviour of, say, the free layer of a spin-tunnel junction or spin-valve depends not only on the factors described above but also on whether any stray field arises from the other magnetic layers in the stack. If present, the preferred orientation of the free layer in the absence of an applied field can be affected. Examples to illustrate all the above will be presented.

I37

The Physics of Arrays of Submicron Magnetic Nanostructures

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Electron beam lithography is a powerful technique which allows the preparation and control of arrays of small magnetic dots. In this way, we have fabricated: triangular, recatangular and square lattices, lines etc. of submicrometer magnetic dots (Ni, Co and Fe). We have studied the magnetic and transport properties of these arrays using a variety of techniques including magnetotransport, magnetization, Magnetic Force Microscopy and light scattering.. We have shown that we can prepare single domain magnetic particles of a variety of materials. When these are incorporated in a variety of regular arrays, the magnetic hystheresis varies from fully coupled to completely decoupled situations. The magnetic hystheresis of small arrays can, in some favorable cases, be determined from a measurement of the anisotropic magnetotransport. The interaction between an ordered array of small magneticparticles and a superconducting thin film can lead to important pinning effects due to the synchronized interaction with the vortex lattice. The resistivity vs. magnetic field curves present sharp minima close to the transition temperature, whereas the transport critical currents exhibit pronounced maxima. These minima and maxima appear at constant field intervals , clearly related with the lattice parameter of the vortex lattice array. The angular dependence reveals that this interval increases with the angle between the field and the film normal showing that only the perpendicular component of the magnetic field is relevant for this synchronized pinning effect. I will describe a series of experiments and comparisons to address many of the aspects of this interesting collective matching phenomenon.

Work done in collaboration with A. Hoffmann, Y. Jaccard, M-C. Cyrille, F. Sharifi, J. Martin, M. Vélez, J. Nogues, J-M. George, M. Grimsditch, M. J.Van Bael, K. Temst, C. Van Haesendonck, V. V. Moshchalkov and Y.Bruynseraede. Supported by the US-DOE and AFOSR.

I38

Ordered Nanometric Ferromagnetic Tiles, Lines and Dots: a New Tool to Modify Magnetic Properties

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Electron-Beam Lithography is a powerful tool to fabricate ordered metallic nanostructures. This technique uses the electron beam of a scanning electron microscope to define the desired pattern. A sequence of four steps has to be followed to obtain the pattern: 1) the desired pattern is written with the electron beam on a electron sensitive resist layer which covers the conducting film. 2) after writing the pattern the resist is developed 3) if necessary, a film is grown at room temperature on top of the resist and finally 4) a lift-off or etching (when step 3 is skiped) process is carried out. Pattern of 300 □m x 300□□m total area could be done. Two typical examples will be discussed. First, the competition between magnetocrystalline and shape anisotropy in 300 nm wide epitaxial (100) Fe lines obtained on (100) MgO substrate by electron-beam lithography and etching and second one the vortex pinning by different geometrical arrays of 20 nm diameter Ni dots in superconducting Nb films; obtained by electron-beam lithography and lift-off processes.

I39

Magnetic Nanostructures on Vicinal Single Crystal Surfaces

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If the lateral dimensions of a ferromagnet are limited on a nanoscale, surprising new phenomena will show up. There are only a few preparation techniques and analytical tools available for these lengthscales. Self-organized growth mechanisms provide a promising preparation technique for nanostructures resulting in large areas of regular nanostructure arrays. This means a mass production of ferromagnetic structures with nanoscale dimensions that all have the same magnetic properties. For the characterization one can use analytical tools that integrate over a certain area like Kerr magnetometry. However, the interaction of neighboring structures has to be considered, too. We focus on Fe-nanostructures grown on a vicinal W(110) single crystal surface. A small miscut angle results in parallel monoatomic steps with a regular spacing of the order of 20 nm. At elevated substrate temperatures during the growth, Fe atoms grow in continuous stripes of one or two atomic layers parallel to the W substrate steps. The distance and the width of the stripes can be controlled by the miscut angle and by the total coverage. The reduced dimension of these structures allows an easier approach as well to the properties of isolated stripes as to the interpretation of the interaction of neighboring stripes. In the case of submonolayer coverage separated stripes of monoatomic height are formed which show a new type of magnetic phase transition. Despite the prediction from the one-dimensional Ising-model, they exhibit a sharp phase transition to ferromagnetic order, free from relaxation. The magnetic easy axis is in the plane, but across the stripes. This cross-magnetization induces ferromagnetic dipolar coupling between the spin-blocks in adjacent stripes, which are performed by exchange interactions. The resulting superferromagnetic phase transition is therefore driven by dipolar interactions. Fe films between one and two atomic layers grow in a periodic array of monolayer and doublelayer stripes. We observed a perpendicular magnetic easy axis in the doublelayer stripes. Because of the dipolar interaction the magnetization shows antiparallel in adjacent double layer stripes. During the adsorption of CO the easy axis rotates into the film plane, which causes a transition from antiferromagnetic dipolar coupling to ferromagnetic coupling. We interpret the observed Kerr loops in terms of a one-dimensional micromagnetic model.

I40

Magnetic Force Microscopy in the Presence of a Rotating Magnetic Field

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We have built and optimized a magnetic force microscope (MFM). The MFM can be operated down to liquid helium temperatures and an external magnetic field can be applied in all possible spatial directions. A compact vector rotate magnet has been constructed by combining three pairs of Helmholtz coils and allows to reach magnetic fields up to 50 mT. The MFM detection is based on commercially available piezoresistive cantilevers (Park Scientific Instruments). An improved sensitivity (0.2 pN/nm) is obtained by using a higher flexural mode of the cantilever. The magnetic tip coating is optimized by relying on Co/Au multilayers grown by molecular beam epitaxy (MBE). With our MFM we have studied the magnetic behavior of patterned Co films with micrometer dimensions. Square Co islands ($1 \times 1\ \mu m^2$) as well as zigzag wires having a width of 1 μm are fabricated by combining electron-beam lithography and lift-off techniques. For that purpose 35-nm-thick Co films, covered by a 5-nm-thick protective Ag layer, are grown by MBE on oxidized Si substrates. When turning on a magnetic field, the evolution of the in-plane magnetic domain structure can be monitored for individual Co islands and for the zigzag wires. The experimental data for the square Co islands are compared to the results of micromagnetic calculations. Two different domain configurations have been detected in the zigzag wires when changing the orientation of the magnetic field within the plane of the Co film. The MFM pictures of the zigzag wires allow an improved understanding of the operation of magnetoresistive sensors.

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I41

Manipulating the Onset of the Magnetization Reversal in Magnetic Nanowires

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The investigation of the magnetization reversal dynamics requires the preparation of magnetic states in which a single domain wall can be nucleated and its motion be traced during the switching process. For such studies, magnetic nanowires with diameters on the order of the domain wall width and of micrometer length are well suited. In this paper, it is shown how for Co and Ni nanowires, prepared by electrodeposition in a track etched polycarbonate membrane, a single domain wall or a multiple number of domain walls can be created in a single wire. In consequence, the onset of the magnetization reversal in such prepared wires can be shifted to a lower field value as compared to single domain wires. The Ni and Co nanowires with diameters on the order of 30-50nm diameter are characterized by an effective easy axis oriented close to the wire axis. It has recently been shown [1], that for such systems domain walls occur only across the short wire axis, separating two domains, with magnetization parallel and antiparallel to the wire axis. These domain walls are clearly evidenced by magnetic force microscopy (MFM) on single magnetic wires after saturation in a field perpendicular to the wire axis, see Fig. 1. In contrast, saturation in a field parallel to the wire axis leads to a single domain state. For such two differently prepared initial states, the onset of the reversal in a field parallel to the wire axis is governed by different processes. For the single domain state, the onset is determined by the nucleation of a wall at one extremity at a field Hn, whereas for the multidomain state, the depinning field Hp of the domain walls determines the reversal. Thus, with walls present inside the wire, the onset of the reversal in a parallel field can be lowered. While the saturation in a perpendicular field creates a number of domain walls at arbitrary positions, a single domain wall can be injected by cycling the applied field parallel to the wire axis between the nucleation field Hn and the depinning field Hp. The described processes are demonstrated by measurements of the anisotropic magneto-resistance (AMR) and by MFM microscopy on single wires as well as by alternating gradient magnetometry on a large ensemble of nanowires.

[1] Y. Henry et. al. Preprint

O17

Engineering the Hysteresis Properties of Thin Films by Lithographically defined non-Magnetic Nanostrutures: A Micromagnetic Study.

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The extraordinary development of nanofabrication techniques offers unprecedent capabilities in the manipulation of material structures and properties, opening up new ways for tailoring magnetic materials and devices [i,ii]. Magnetic sensors[2] and ultra-high-density magnetic storage[iii] are some of the fields in which nanostructures are being proposed as the future high performance systems. In this work, a micromagnetic study of lithographically defined periodic non-magnetic nano-rectangles in thin magnetic films is presented. Hysteresis loops have been computed for different sizes and separations of the non-magnetic structures and several directions of the applied field. In order to control the magnetic properties more efficiently in these structures, no magnetocrystalline anisotropy has been considered. In fact, experimental techniques for thin film fabrication like thermal evaporation are used in order to eliminate crystalline anisotropy[2] when applying nano-dots to high-density storage. Consequently, the behaviour of the material is fully described by the geometry (size and separation of the non-magnetic structure and thickness of the film) and the exchange length ($l_{exch}= (C/2pM_s^2)^{1/2}$). In our model, the computational region is discretized in a regular square mesh and periodic boundary conditions are imposed. Hysteresis loops have been computed by solving the micromagnetic equilibrium equation for each applied field. Numerical details of our simulation can be found in a former paper[iv]. It is observed that the hysteresis properties can be modulated in a wide range by choosing the adequate geometric parameters in a given material. For example, in rectangle arrays of size ratio 5:1, the coercivity changes in two orders of magnitude depending on the applied field angle. In addition, our results reinforce the possible application of these systems as ultra high density storage media. Remanent states adequate for this purpose have been obtained for areal densities up to 750 Gbits/in^2.

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O18

Magnetic Domain Structure in Ni (001) Sub-micron Particles

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The magnetic properties of two-dimensional arrays of Ni particles with well-defined geometry, prepared by electron lithography from epitaxial Ni (100) films of thickness 60 nm, have been studied. Single crystal Ni films were deposited in a dc planar magnetron sputtering system. Circular particles prepared as octagons with diameters 0.6 μm and rectangular particles, 0.9 μm x 0.3 μm, were positioned in square and rectangular lattices, respectively, with lattice constants about twice the particle dimensions. Magnetic Force Microscopy (MFM) images were obtained with a Dimension™ 3000 Scanning Probe Microscope from Digital Instruments. The microscopic, as well as the macroscopic (1), measurements showed that the particles comprise multi-domains in zero-field. An illustration is given in the MFM image of a sample with circular particles in a lattice oriented along the <110> directions, cf fig.1. The feature with magnetic contrast extending outside the particles may be explained by modelling the MFM image for dipolar magnetic interaction between sample and tip.

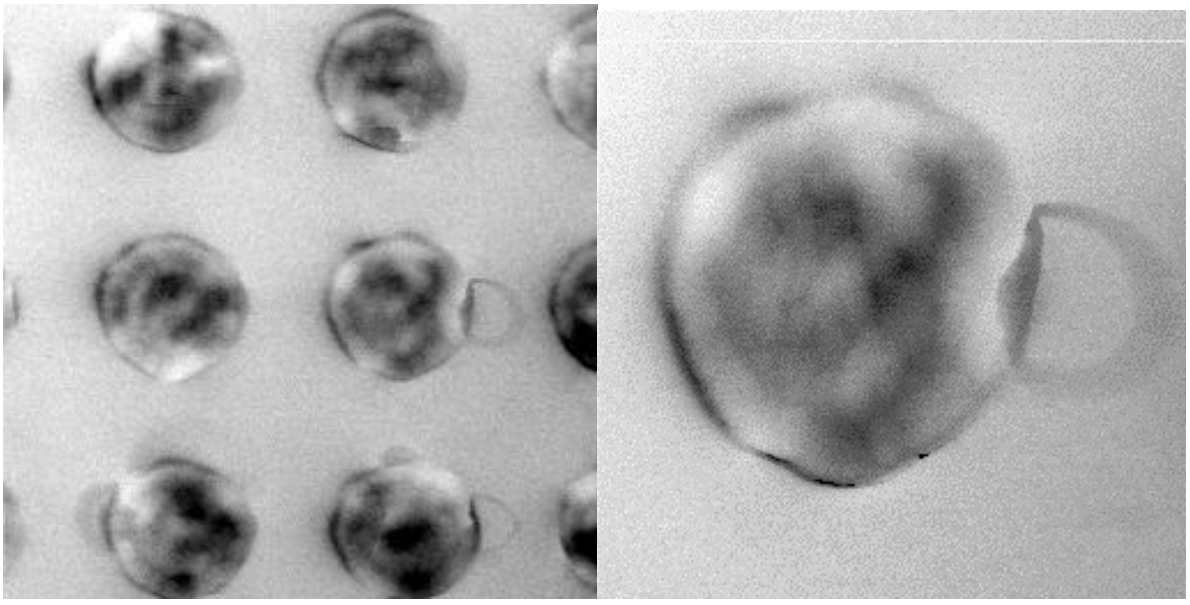

Fig. 1. *MFM images of Ni particles with the lattice oriented in the <110> directions. The lattice constant is 1.1 μm.*

1. M. Hanson, C. Johansson, B. Nilsson, and E. Svedberg. To be published.

I42

Magnetic Dynamics of Fine Particles Studied by Inelastic Neutron Scattering

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The inelastic neutron scattering (INS) technique provides a way to obtain information about the magnetic dynamics of superparamagnetic fine particles on very short time scales. We describe how INS can be used to obtain information about both the longitudinal fluctuations of the magnetic moment between the easy directions and the transverse fluctuations of the magnetic moment near an easy direction. We discuss recent INS results on a sample of 15 nm antiferromagnetic (-Fe_2O_3 fine particles, where both types of fluctuations have been studied simultaneously as a function of temperature and applied magnetic fields. This study is compared to other recent studies on ferromagnetic fine particles, and advantages and disadvantages of studying ferromagnetic and antiferromagnetic fine particles by the INS technique are elaborated.

I43

Erasing Glassy State in Small Particle Systems

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A detailed study of the static and dynamic magnetic properties of nanocrystalline barium hexaferrite powder was done. Particles of about 10 nm diameter exhibit the main features attributed to glassy behaviour, such as ageing and magnetic training phenomena and very high field irreversibility in the hysteresis loops and in the zero-field-cooling/field-cooling curves. This glassy state is mostly attributed to the frustration induced by magnetic interactions between randomly distributed particles, although some authors suggest the dominant role of surface spins. The effective energy barrier distribution obtained from the analysis of the time dependence of the thermoremanence in terms of the Tln(t/t0) scaling shows a maximum located at energies higher than the mean anisotropy energy barrier. When doing the relaxation experiments after field cooling at increasing fields, the obtained effective energy distribution progressively resembles the anisotropy energy distribution. In order to clarify the roll played by the interparticle interactions, two samples with different proportion of silica powder were studied. The results show how, although the main cited features do not completely disappear, the effective energy barrier distributions present a maximum at low energies, and its importance increases with the "dilution" of the original powder.

O19

Superparamagnetic Relaxation And The Effect of Inter-Particle Interactions For NiO Nanoparticles.

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The magnetic properties and dynamics of NiO nanoparticles, doped with ^{57}Co, have been studied with Mössbauer spectroscopy and magnetization measurements. The particles were produce by thermal annealing at 300(C of chemically produced $Ni(OH)_2$, doping with about 0.5 at.% ^{57}Co (relative to the Ni content) resulting in a dry sample of agglomerated particles with a disk shape with thickness of about ... nm and a typical diameter of about ... nm. In order to study the effect of inter-particle interaction a part of the sample was treated to separate the particles and the isolated particles were coated. Mössbauer spectra of the uncoated sample exhibited magnetic splitting at temperatures much higher than the uncoated sample. This shows that inter-particle interactions between the antiferromagnetic particles is very important for the magnetic behavior of such particles. Similar behavior has been observed for weakly ferromagnetic (WF) hematite nanoparticles. A Mössbauer spectrum obtained at 5 K with a magnetic field of 6 Tesla applied indicates that the particle moment is dominated by the uncompensated particle moment along the direction of the sublattice magnetization. This is in contrast to that found for WF hematite particles where the particle moment has been found to be perpendicular to the sublattice magnetization as it is dominated by the canting of the moments. The different origin of the particle moment is found to be important for the magnetic relaxation of the particle moment and lead to different magnetic behavior of NiO and hematite nanoparticles.

O20

Modeling of Interaction Effects in Granular Systems

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The effects of particle interactions on the magnetic behavior of granular solid systems are examined using a numerical model. The model takes into account the effects of particle size and easy axes distributions, and capable of predicting the field, temperature and time dependence of magnetic properties. In this work interaction effects on the temperature dependence of the time viscosity coefficient (S), and the behavior of minor hysteresis loops are examined using a mean field approach. For time dependence effects, interactions are found to have great effects on the shape of the effective energy barrier distribution f(ΔE) obtained from the temperature decay of remanence. This result is found to be consistent with a previous result obtained using a general model that based on Monte-Carlo simulation of interaction effects [1]. These changes in f(ΔE) can easily give a temperature independent behavior of S. Thus conclusions about macroscopic quantum tunneling must be carefully drawn from the temperature dependence of S. For minor hysteresis effects, the result shows that for the non-interacting case, no minor hysteresis loops occur, and the loops are only predicted when the interaction field is positive. From these predictions, minor loops will form when the interaction field is strong enough to magnetize some moments during the recoil process back to zero field. Thus these minor loops are originated from interaction driving irreversible changes along the recoil curve and the irreversible component of magnetization has no direct influence on the formation of these minor loops.

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O21

Effect of Interparticle Interactions in Nanosized α-Fe_2O_3 /Al_2O_3 System

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The magnetic properties of α-Fe_2O_3 nanoparticles (average diameter 3nm) in alumina (68% α-Fe_2O_3 in weight) have been investigated by magnetization vs temperature, field and time measurements. The results provide evidence of interparticle interactions. With decreasing temperature, the assembly of particle moments progressively block according to their actual anistropy energy barrrier (affected by interparticle interactions), entering the irreversible regime at $T \approx 180K$. A further decrease of temperature leads to a maximum ($T \approx 150K$) of both the the zero field cooled and field cooled magnetization, resulting from a combination of single particle anisotropy and collective effects. Even hysteresis loops show different features above and below $\approx$ 60K. For T> 60 K the first magnetization curve lies within the cycles, as expected for non-weak interacting particles, whereas for T< 60K it is found below the remagnetizing branch of the cycle. Moreover, the coercive field vs temperature shows a maximum at $\approx$ 60K, signalling the presence of interparticle iteractions. All such evidences seem to lend support to the existence below 60 K of a surface-mediated collective freezing of particle moments in random directions .

O22

Thermal Effects and Anisotropy in Particles for Magnetic Recording Media

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The thermal stability of the magnetic properties of particles to be used in advanced recording media is analysed with measurement of time dependence of the magnetization, and deduction of magnetic viscosity, fluctuation field and activation volume. The analysed materials include pure and Co-doped iron oxide particles, pure and Fe-doped chromium dioxide particles, pure and Co/Ti-doped Ba ferrite particles, and Fe metal particles. In the same materials the magnetic anisotropy and its distribution are experimentally investigated through the second derivative of the magnetization curve from saturation to remanence measured perpendicularly to the alignment direction [1]. The ionic additions change the magnetic anisotropy and the coercivity of the materials, and the mean anisotropy field in the distribution regularly follows this evolution, increasing with doping in iron oxide and chromium dioxide, and decreasing in Ba ferrite. The width of anisotropy distribution shows a different behaviour, and it increases with doping in all materials, which we can impute to the non-collinearity of shape and magnetocrystalline anisotropy in doped particles, and to the nonuniform doping content from particle to particle and inside the particles themselves. The magnetization decays result larger and the activation volume smaller in modified particles, which indicates a worse magnetic stability, both when the doping increases and when it decreases the anisotropy. Therefore the magnetic stability is not simply directly related with the mean anisotropy field. However, the evolution of the anisotropy distribution width is consistent with the change in thermal stability: when the width increases, the magnetization is less stable. This is interpreted considering the evolution of the magnetization switching in the particles, we study mainly with analysis of the rotational hysteresis energy loss behaviour. It indicates an evolution of the switching with doping. In modified particles, wich have bad magnetic order and consequent larger anisotropy distribution, the reversal is incoherent with a larger likelyhood, with consequent poorer stability of the magnetization.

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O23

Magnetic Behaviour And Percolation In Mechanically Alloyed Fe-SiO_2 Granular Solids

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Fine magnetic particles have been extensively studied in the last years due to their interest for both applications -such as magnetic recording media, sensors, ferrofluids or catalists- and fundamental physics. However, the combined effects of many different factors gives rise to a complex magnetic behaviour which requires further experimental work for full clarification. Among those factors we can include, in addition to the intrinsic properties of the magnetic particles, size effects, surface anisotropy, size and shape distribution, and degree of dispersion in a matrix. In this work we present an analysis of the magnetic properties of mechanically alloyed Fe nanoparticles dispersed in SiO_2 with Fe volume concentrations ranging from 10% to 60%, that is, from high dilution to above the percolation limit. The mean grain size, as measured by XRD, lies between 15 and 18 nm for all compositions, although TEM images have shown that the size and shape distribution is very broad. In particular, small particles, under approximately 20 nm, tend to be spherical and isolated in the SiO_2 matrix, while larger particles are usually polyhedrical and unequiaxed and form aglomerates that, in the case of samples with over 50% Fe, compose the majority of the sample. The room temperature coercive force presents a clear peak for the samples with 30% Fe, with H_c=400 Oe, and decreases sharply for those above the percolation limit, a similar evolution being observed for the reduced remanence. The saturation magnetization of the samples exhibits a linear dependence on the composition, indicating that the percentage of blocked grains is the same for all samples. The analysis of the magnetic interactions as a function of the composition and temperature, by means of the isothermal and demagnetization remanence curves (IRM and DCD, respectively), as well as the little variation of grain size with the composition, allowed us to analyse the role played by the interactions in the reversal mechanism of our samples.

O24

Enhancement Of Room Temperature Coercivity By Mechanical Alloying Ferromagnetic And Antiferromagnetic Materials

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Mechanical alloying soft and hard magnetic materials introduces exchange interactions between both materials, which are one of the origins of the remanence enhancement in hard magnetic materials [1]. Similar effects have also been found in soft-hard thin film and multilayer systems [2]. Exchange interactions between ferromagnetic and antiferromagnetic materials have been mainly studied in thin film systems of transition metal particles embedded in their native oxide. These systems exhibit a shift of the hysteresis loop in the field axis (exchange bias, H_E) and an increase of coercivity below the Néel temperature of the antiferromagnet [3]. We have studied the effect of mechanically alloying ferromagnetic (e.g. Co) and antiferromagnetic materials, with Néel temperature above room temperature (e.g. NiO, T_N = 590 K or FeS, T_N = 610 K), in order to induce exchange interactions to enhance the room temperature coercivity of the ferromagnetic material. We found that after annealing above T_N and field cooling to room temperature, the alloys exhibit a substantial increase of the room temperature coercivity, H_C. We will discuss the role of the annealing temperature, cooling field, measuring temperature as well as the optimum ratio of ferromagnetic/antiferromagnetic powders, to observe this increase in H_C. The presence of loop shifts, and the dependence of H_C and H_E on the annealing and measuring temperatures suggest that exchange bias effects [3] are responsible for the observed enhancement of the coercivity.

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O25

Magnetic and Electromagnetic Properties of Superparamagnetic Nanocomposites.

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We report here new experimental results on superparamagnetic cermets made of Ni nanoparticles embedded in Alumna matrix. Magnetic measurements are performed on a S.Q.U.I.D. magnetometer and optical measurements are performed on a Fourier transform spectrometer in the far infrared range. Some anomalous magnetic properties may be attributed either to an exchange coupling between ferromagnetic and antiferromagnetic or ferrimagnetic phases in consolidated nanostructured Ni [1], or to finite size effects in antiferromagnetic NiO nanoparticles [2]. Our superparamagnetic nanoparticles exhibit hysteresis loops which are open up to 1 Tesla and do not saturate. But no shifted hysteresis loop is observed after field cooling, while T.E.M. and atomic concentration measurements show up the presence of NiO. As optical measurements have been proved to be relevant to investigate superparamagnetism relaxation [3], we compare experimental transmission measurements with calculation based on the Onsager local field, taking into account the permanent magnetic moments of the particles [4]. Usually, superparamagnetic relaxation is understood by comparing the relaxation time τ of the particle magnetic moment with the measuring time τ_m. In our case, τ_m is given by the electromagnetic wave period. According to Neèl's model [5] τ is temperature dependent. Different dominant anisotropy involved in this dependence lead to different transmission behavior while changing sample temperature from 5 to 300 Kelvin.

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Characterization of Amorphous Fe-Ni-B Magnetic Nanoparticles Synthesized by Chemical Route

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We have synthesized Fe-Ni-B amorphous nanoparticles by chemical reduction of a transition metal solution showing that the chemical reduction of aqueous solutions of metal salts by $NaBH_4$ proves to be a successful method for prepared these samples. A compositional study shows that the nominal Ni-Fe ratio was obtained for all concentrations. In contrast, the boron composition observed is higher than the one obtained by traditional rapid-quenching synthesis (~20 at.%). Moreover, the boron concentration in our samples is notoriously higher than the values found in the literature using other chemical reduction methods. X-ray powder diffraction and transmission electron microscopy indicate an amorphous nature of the particles with mean particles size ~15-20 Å diameter for all compositions. Magnetic measurements confirm this mean particle size with a narrow log-normal size distribution.