

Workshop on Magnetic Fluids
International Center of Condensed Matter Physics
Universidade de Brasília
Brasília - Brazil - September, 11 - 15, 2000

Chairpersons: Régine Perzynski (U.P.M.C. - Paris, France)
Francisco A. Tourinho (UnB - Brasília, Brazil)

Organizing committee:

Jérôme Depeyrot	(UnB - Brasília)
Maria C. F. Lima e Lara	(UnB - Brasília)
Geraldo J. da Silva	(UnB - Brasília)
Antonio M. Figueiredo Neto	(USP - São Paulo)
José A. Miranda	(UFPe - Recife)
Hans D. Pfannes	(UFMG - Belo Horizonte)
Claudio Scherrer	(UFRGS - Porto Alegre)

Magnetic fluids (MF) are stable colloidal solutions of magnetic nanoparticles dispersed in a carrier that can be either a polar or a non-polar liquid. This carrier can also be a more complex system, such as a polymeric solution, a gel, or a liquid crystal. These materials are of interest for both chemists and physicists. Thanks to the unusual association between the magnetic and the fluid properties of the carrier, the experimentalist has at his disposal a powerful external parameter, the magnetic field. This is the original feature of the MF with respect to ordinary fluids. The strength of this external parameter leads to numerous and various applications, from rotating shafts in the hard disk system of microcomputers to assisted dampers of truck seats and optical shutters of missile pointers. All these technical applications bring up a lot of new problems. A very active community of theoreticians has undertaken the task to tackle these problems. Conformational instabilities, which lead to peaks, labyrinthine patterns or magnetic starfishes, are good examples of specific MF.

MF do not exist in nature. To be stable at a colloidal level, and to prevent the agglomeration of the nanoparticles under van der Waals magnetic dipolar interactions, it is necessary to invoke a certain degree of interparticle repulsion inside the colloidal solution. This repulsion is either steric or electrostatic. It is produced either by a surfactant coating of the nanoparticles or by a superficial density of electrostatic charge. These materials are thus the product of sophisticated colloidal syntheses. They have also a promising future in biochemical, biophysical and medical applications. They can be used as a drug carrier, as a contrast agent in magnetic resonance imaging, and in magneto-thermal therapies of some cancers.

Works on magnetic fluids have begun in the USA in the early sixties, with the invention of these materials by Professor Ronald E. Rosensweig in the context of a spatial program. Since then, the international community that works with these fluid systems has been growing regularly, including scientists belonging to the western world (and Japan) and to the former Soviet Union. Every three years, large conferences bring together the whole international community. The main poles of research on MF are located in the USA (California, Florida, Massachusetts, Pennsylvania), Japan (Akita, Kyoto, Sendai, Tokyo), western Europe (France, Germany, Ireland, Netherland, Norway, Spain, United Kingdom), eastern Europe (Hungary, Latvia, Romania, Russia, Slovakia), Brazil, and India.

In Brazil, the MF community extends all over the country at different states (Brasília, Goiás, Minas Gerais, Paraná, Pernambuco, Rio de Janeiro, Rio Grande do Sul, São Paulo). This community includes chemists, physicists and biophysicists. The organization of a one-week meeting in Brazil appears as an exceptional opportunity for the whole Brazilian MF community to get together and to establish close contacts with the foreign invited lecturers. The Workshop on Magnetic Fluids has been organized by Prof. Régine Perzynski (U.P.M.C., Paris, France) and Prof. Francisco A. Tourinho (UnB, Brasília, Brazil) in Brasília, from September 11 to 15, 2000. It adopted a format of one-hour presentations, allowing the lectures to be detailed and pedagogical. In this respect, it was held in a clearly different spirit from the international MF conferences.

All the 26 oral presentations were invited talks (12 from Brazil, 14 from outside Brazil). The following nine foreign scientists have give oral presentations: Michael Widom, Pittsburgh, USA, Balachandran Jeyadevan, Sendai, Japan, Stefan Odenbach, from Bremen, Germany, Jean-Claude Bacri, Emmanuelle Dubois, and Régine Perzynski, from Paris, France, Elmar Blums and Andrejs Cebers, from Riga, Latvia, and Yuri Raikher, from Perm, Russia. Five

of these invited lecturers have presented two different one-hour long talks. Unfortunately, two of the invited talks have been cancelled at the last moment (we are sorry that Ronald Rosensweig, from the USA, and Rosângela Itri, from Brazil, could not attend the meeting). There were twelve Brazilian invited speakers: Jérôme Depeyrot, Joel C. Rubim, and Francisco A. Tourinho, from Brasília, Bismarck V. da Costa, P. Licinio, and Hans-Dieter Pfannes, from Belo Horizonte, Luiz R. Evangelista, from Maringá, Paraná, José A. Miranda, from Recife, Constantino Tsallis, from Rio de Janeiro, Claudio Scherrer, from Porto Alegre, and Antonio M. Figueiredo Neto and Hercilio R. Rechenberg, from São Paulo. A poster session has been included, with a brief presentation of the 20 posters on the first day of the workshop. All the poster applications to the workshop have been accepted, allowing anyone to participate and to present his own scientific work.

The Workshop on Magnetic Fluids was held in the International Center of Condensed Matter Physics in Brasília. The Center has provided a very professional assistance. In particular, we thank Prof. Hugo Nazareno, chairman of the Center, for all his support to the scientific and technical organization of the meeting.

We heartily thank all the sponsors that have provided the organizing committee with financial support to the workshop, namely, the Brazilian agencies CAPES-COFECUB, CNPq, FAPDF, FUBRA, the Ambassade de France and, very specially, Prof. Lauro Morhy, Rector of the University of Brasília. We also deeply thank all the referees for their work without which these proceedings could not have appeared.

From a scientific point of view the scope of the conference can be divided into five different thematic parts:

- **Nanoparticle synthesis.** Two different kinds of synthesis were presented and discussed: (i) chemical synthesis of ionic MF (E. Dubois and F. Tourinho); (ii) mechanical synthesis by ball milling (H. R. Rechenberg); 3 posters were related to this topic.

- **Colloidal stability, structure and rheology.** There were several experimental works using various techniques, such as small angle neutron scattering (E. Dubois), static and dynamical light scattering (B. Jeyadevan, P. Licinio), rheological measurements (S. Odenbach) to probe the existence, depending of the experimental situation, of three-dimensional structures inside the colloid. Structures in the vicinity of a wall cell, due to the wetting of the MF, were also discussed (A. Figueiredo Neto). Monte Carlo simulations (B. da Costa) gave a supplementary vision of the local structures that MF may develop in an applied field; 2 posters and 3 articles were related to these points.

- **Magnetic properties - statics and dynamics.** Experimental studies using various techniques have been presented: magnetization measurements, Mossbauer spectroscopy, and Raman spectroscopy. They have given a good insight into the internal structure of nanoparticles (J. Depeyrot, H-D Pfannes, H. R. Rechenberg, and J. Rubim). Several theoretical works were directed to enlighten the description of magneto-dipolar systems from a thermostistical point of view (Yu. Raikher, C. Scherrer, C. Tsallis, and M. Widom) and to address heat and mass transfer properties (E. Blums); 8 posters and 8 articles were related to these topics.

- **2D-patterns and instabilities.** The interesting topic of 2D-patterns in Hele-Shaw cells in a magnetic field was illustrated by several theoretical talks (A. Cebers, J. Miranda, and M. Widom). Several aspects of magnetodynamic instabilities have been illustrated by experimental works on surface waves at an interface (R. Perzynski) and drop instabilities; 2 posters and 4 articles were related to the topics. From the point of view of complex subsystems, there were also presentations on liquid crystals (L. Evangelista), magneto-liposomes (R. Perzynski), and a review on biological applications (J. C. Bacri); 5 posters were related to these experimental topics.

In conclusion, this workshop was a great success. It has brought together scientists working on MF from all around the world. It has given an extended view on the various ways to approach the study of MF, both from the experimental and from the theoretical point of view, analytically and also by means of numerical simulations. Such events are very important, in particular for students. They give rise to the establishment of contacts and collaborations. They are also the place to confront various scientific approaches of similar problems, by different teams. New results and analyses have been presented on different problems, such as:

- *the spatial structure of the phase separated MF solutions at the scale of a few μm* ; it appears to be different, depending on the colloidal conditions, and leading either to an aggregation or to a liquid-gas like phase separation;

- *the internal structure of the nanoparticles at a scale lower than 10 nm*; the simple monodomain structures seem to fail for the smallest nanoparticles, a non-magnetic surface layer becoming obviously important.

A wealth of new experiments have been proposed by the theoreticians. In particular, the observation of new two-dimensional dynamical patterns or of a magnetic stochastic resonance in nanoparticles. Also, biological applications of MF appear as an enormous perspective for the future, full of rich potentialities. We anticipate impressive accomplishments by collaborations among chemists, physicists and biologists.

During the 9th International Conference on Magnetic Fluids (held in July 2001, in Bremen, Germany) the International Steering Committee has proposed that the next ICMF (ICMF10) will be held in Brazil (in the resort town of Guarujá, São Paulo) in July, 2004, under the joint responsibility of Antonio M. Figueiredo Neto (USP), Francisco A. Tourinho (UnB), Jérôme Depeyrot (UnB), and José A. Miranda (UFPE).

Jérôme Depeyrot - (UnB, Brasília, Brazil)
Régine Perzynski - (U.P.M.C., Paris, France)
Francisco A. Tourinho - (UnB, Brasília, Brazil)

Guest editors