Recent and Current Mesoscopic Projects
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- *Kondo and Local Moment Behavior in Thin Metal Films.*
We have been studying the Kondo effect and local moment physics in thin metal films for several years. During the past year or so these experiments have been quite productive (see the publication list), and have led to the Ph.D. thesis of Todd Jacobs (who has now taken a job at Motorola). Our goal is to better understand two specific aspects of this problem: the effect of system size, and the influence of disorder. With regards to system size, we have designed experiments to determine how the nature of the local moment is affected by proximity to a surface. The results are, for the most part, in good agreement with a recent theory developed by Alfred Zawadowski and coworkers. We have also discovered an unanticipated dependence on substrate preparation, which seems to be explicable in terms of the Zawadowski mechanism. With regards to the effect of disorder, we have studied how the Kondo contribution to the resistivity is suppressed as the disorder is increased by decreasing the elastic mean-free-path. This suppression has been addressed by a theoretical model developed by Philip Phillips and coworkers. Our new results have enabled us to make the first stringent tests of this model, and we have found that the original Phillips model is *not* capable of accounting for our observations. However, some modifications of that theoretical picture have been advanced very recently, and we are trying to reconcile it with our experiments. Hence, while we seem to be getting closer, we still have not arrived at a theoretical understanding of how disorder affects the Kondo effect in simple metal systems.

- *Flow of Classical Fluids in Lithographically Produced Nanostructures.*
We are engaged in a project whose goal is to develop lithographic methods for fabricating fluid flow structures at the nanometer scale, and to use these structures to study the flow of classical fluids. We have developed several approaches for making flow structures in which at least one dimension is as small as 50 nm. It has also been necessary to develop special techniques for measuring the very small flow rates found in these structures. Preliminary results for the flow of water indicate that the absolute rate of pressure driven (Poiseuille) flow agrees well with the simplest theory, which assumes no-slip boundary conditions at the boundaries of the flow channel. However, our very recent results for some "long" chain hydrocarbons, including decane and hexadecane, show that slip has a large effect on the flow when the channel height is reduced below about 100 nm. This is in rough agreement with tribological studies of these fluids using rather different techniques. We hope to soon be able to make quantitative comparisons with recent molecular dynamics studies of this problem.

- *Electron Transport in Narrow Ferromagnetic Wires.*
We are studying the transport properties of very narrow (30 nm) ferromagnetic

wires composed of Ni. In experiments several years ago our group observed the resistance associated with a domain wall in such a wire, and found that it can be negative. That is, a narrow Ni wire which contains domain walls has a lower resistance than the same wire when no walls are present. The origin of this negative wall resistance is not yet clear, although several theories have been proposed, and a similar negative resistance has been observed by other groups in other materials. During the past year we have initiated a new series of experiments in this area. In some of our latest measurements we have found that a rather modest ($\sim$ 200 Oe) magnetic field applied perpendicular to the axis of a wire can induce the nucleation of new domain walls, and we have been able to observe the resistance decrease due to individual walls as they enter the sample. This value for the resistance of a single domain wall will, we hope, provide a strong test of the theories which have been proposed. For the near future we plan to study the wall resistance in a variety of materials to determine how it depends on anisotropy, etc. We suspect that our negative wall resistance may be related to the giant magnetoresistive effects found in other materials, so what we learn about the domain wall resistance should be of very wide interest to the magnetics community.

- *Other Work.*
  During the past year we spent a modest amount of time on a collaboration with a group from the Naval Research Laboratory, which includes A. Gulian and K. Wood. They have devised a scheme for using the relatively large thermoelectric coefficient found in Kondo systems to make a sensitive detector of UV and X-ray photons for use in astronomy. Our role in this collaboration has been to use our thin film and lithographic expertise to fabricate several prototype devices, whose performance as detectors was then studied at NRL. The initial results were promising, and because of this success the project warrants increasing fabrication effort. Unfortunately our resources (particularly with regards to manpower) are limited, so we have had to discontinue our work on this collaboration. However, this preliminary success will likey enable the NRL group to obtain additional resources, so that future fabrication can be done at NRL.

Recent Publications

1. Kondo effect in small metal systems, N. Giordano and T. M. Jacobs, Physica B **280**, 434 (2000).

2. Substrate dependence of Kondo and local moment physics in thin metal films, N. Giordano and T. M. Jacobs, J. Appl. Phys. **87**, 6079 (2000).

3. Kondo behavior of multilayers: Local-moment physics near surfaces, T. M. Jacobs and N. Giordano, Phys. Rev. B, in press (December) (2000).

4. Effect of disorder on the Kondo behavior of thin Cu(Mn) films, T. M. Jacobs and N. Giordano, in *Size Dependent Magnetic Scattering*, in the NATO Science Series, Kluwer Academic Publishers, in press.

5. Domain wall resistance and magnetoresistance of narrow ferromagnetic wires, B. Çetin and N. Giordano, J. Materials Sci. and Eng., in press.