Fig. 2 Magnetic satellite peaks in the diffraction pattern of spiral-phase holmium (inset) are related to the repeat length of the magnetic spiral. As the temperature increases, the repeat length becomes shorter (moves right; the units of abscissa are inverse length). (From ref. 4.)

from the K (innermost-electron) atomic shell, which is also spherical. But there should be an effect for the higher $2p$ core states, which are not. The observed resonances do not seem to occur through relativistic spin-dependent processes advocated previously⁵ and invoked in the interpretation of resonant magnetic effects in ferromagnetic nickel⁶.

There are common features between the direct magnetic interactions of neutrons and photons with unpaired electrons⁷. In particular, both couple to the electron spin and current (orbital) densities and their scattering amplitudes depend on the polarization of the incident beams. The latter effect has been exploited for many years in neutron diffraction, to obtain high-precision maps of the magnetization density throughout crystal unit cells. Changing the magnetic scattering amplitude by changing the polarization of the incident beam provides good signal sensitivity and preserves the state of the target sample. Magnetization density maps supplement independent data, obtained with nuclear-magnetic-resonance and Mössbauer techniques for example, and provide stringent tests of our understanding of highly correlated magnetic states in metals and compounds, including covalency effects.

Whereas the magnetic neutron interaction can be derived from a classical picture of the neutron magnetic moment interacting with the electronic moments and current, the magnetic photon interaction is a relativistic effect and not so readily visualized. A correction to Thomson scattering, it is a relatively weak effect for photon energies small compared with the electron rest mass (511 keV). Even with synchrotron sources, to discriminate it unambiguously in the scattered signal poses problems for the experimentalist. At present, the advantages of magnetic photon scattering over neutron scattering are seen to be the possibility of separating the spin and current

contributions in the amplitude, and its relatively good wave-vector resolution⁸.

Synchrotron radiation is predominantly linearly polarized in the plane of the electron accelerator, but weaker circularly polarized X-rays are emitted at a slight angle to the plane. Cooper *et al.*³ use this diverging emission in their magnetic Compton (or inelastic) scattering experiment on a single crystal of iron. Circular polarization in the incident photon beam induces interference between the charge and magnetic scattering amplitudes, which is analogous to the nuclear-magnetic interference created by polarized neutron beams.

Cooper *et al.*³ measured the polarization of the unpaired electron spins in the sample as a function of the electron momenta, rather than as a function of spatial distribution. There is a clear difference along the three crystallographic directions, [111], [110] and [100], that they investigated. The data complement those obtained by neutron diffraction and agree largely with predictions from standard quantum theories of magnetic materials.

The experiment is possible because of the high intensity of the present generation of synchrotrons which produce usable intensities of out-of-plane X-rays. The next generation of machines, being built at Argonne National Laboratory and Grenoble, should provide a further hundredfold increase in flux, unlikely to be matched by improvements in neutron sources. □

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Daedalus

Attacking the vapours

MOLECULAR sieves are the most subtle of porous materials. Efficiently and selectively, a molecular sieve absorbs those vapour molecules that fit neatly into its internal cavities. Heat it up, and it will let them out again. Imagine, says Daedalus, a disk of molecular sieve with one side hotter than the other. The cold side will absorb specific vapour molecules from the adjacent gas. The hot side, with a much greater vapour-pressure for those molecules, will evolve them again. The cold side will gain molecules, the hot side will lose them, and the disparity will cause a steady internal molecular drift from cold to hot through the porous structure of the disk. The whole thing is an elegant, selective molecular pump with no moving parts, and DREADCO's engineers are exploiting it vigorously.

The simplest applications only require the pumping of trace gases, and need only modest areas of molecular sieve. Thus the currently fashionable 'sick building syndrome' afflicts offices which, to save energy, are inadequately ventilated. Debilitating organic vapours build up from the staff and electrical equipment inside. Radon is another scary atmospheric trace contaminant of many homes and buildings. In both cases, a DREADCO sieve-pump set in an outside wall could neatly, continuously, and selectively absorb and expel the nasties. A healthy and refreshing environment would be ensured without throwing away expensively heated air or causing draughts. Daedalus's ingenious 'enriched greenhouse' is a converse invention. It is partly panelled with molecular sieve elements absorbing carbon dioxide. As its interior warms up in the sunlight, carbon dioxide is automatically sieved from the atmosphere outside and pumped in. Bathed in light, heat and extra carbon dioxide, the pampered plants within photosynthesize with tropical luxuriance.

Bigger gas flows start to demand significant fluxes of heat. For greatest efficiency, a sieve-pump should maintain its temperature difference by pumping heat continuously from the cold side of the sieve to the hot side. The DREADCO team are accordingly developing a 'sandwich structure' of electrically conducting charcoal-based sieve material, faced with porous bismuth telluride thermoelectrodes. A potential difference across the faces pumps heat, and therefore molecules, in the same direction. Volunteers are already blissfully evaluating DREADCO's pilot Pumpsicks®, which use power from a small battery to expel both heat and water vapour from sweaty feet. A bigger unit, expelling water vapour from a house for air-conditioning and dehumidification, is also feasible. David Jones