University of Caen in France, reported x-ray diffraction studies of the compound with x equal to 0. These investigators deduced a structure with a tetragonal unit cell and no linear copper-oxygen chains, although the lanthanum plane was devoid of oxygen atoms. The Stanford group argued that this may be the structure that they have seen. If so, once again, the conclusion was that linear chains are not necessary for high-temperature superconductivity.

The final piece of evidence from IBM is less direct but indicates how important it is to have good single crystals for sorting out the intricacies of these highly anisotropic superconductors. For example, Debra Kaiser and Frederick Holtzberg of IBM have recently been able to grow single crystals of $YBa_2Cu_3O_7$ with dimensions in the millimeter range. The presence of linear chains implies an approximately one-dimensional character for the superconductivity, and this would be reflected in a parameter called the coherence length, which is a measure of the distance over which the quantum mechanical wave functions of the superconducting electrons extend. The coherence length would be larger in the direction of the chains than in directions perpendicular to them. It is possible to deduce the coherence length from the critical magnetic field, the maximum field at which the material remains superconducting.

A poster presentation by Thomas Worthington, William Gallagher, and Timothy Dinger of IBM reported the outcome of measurements parallel and normal to the linear chains and at several angles in between on single crystals with average dimensions of about 0.2 millimeter on a side. The coherence lengths extracted for the parallel and normal orientations were 34 and 7 angstroms, respectively, both very short as compared to conventional superconductors. It is of particular interest that 7 angstroms is almost a factor of 2 larger than the spacing between the nominally isolated layers separated by rare earth planes. According to this finding, whether or not chains are necessary for high-temperature superconductivity, the macroscopic superconductivity properties are three-dimensional in character rather than two- or one-dimensional.

Good-quality single crystals and thin films could also help sort out several important questions that were hotly debated at the workshop. For example, a fundamental feature of superconductors is an energy gap between the superconducting and normal electronic states. But, as one physicist noted, "At the workshop we had one Nobel laureate saying there is no gap and another Nobel prizewinner arguing that there is." ■

ARTHUR L. ROBINSON

No Satellites of Asteroids

If the object of the search were a person, he would surely by now have been given up as lost for good. But it is companions to asteroids that astronomers have been searching the heavens for and, despite the steadily accumulating negative results, satellites of asteroids may still be out there. It is just that the available ground-based methods seem incapable of finding them, which suggests that the reported sightings that prompted recent efforts were in error.

The latest discouraging word comes from Tom Gehrels, Jack Drummond, and Nancy Levenson of the University of Arizona. While preparations were under way for other work with the Spacewatch Telescope and its charge-coupled device (CCD) detector on Arizona's Kitt Peak, these astronomers searched around the three largest asteroids—Ceres, Vesta, and Pallas—and another seven of the larger asteroids. They found nothing orbiting these asteroids larger than 3 kilometers in diameter as far as tens of thousands or hundreds of thousands of kilometers from the asteroid (depending on the asteroid), where the sun's gravity would wrest away any satellite, to as close as a few thousand or tens of thousands of kilometers. Closer than that, the asteroid's halo of scattered light obscured any close companions.

The Arizona group also reviewed the results of two survey projects completed in the 1950s and 1960s. The Yerkes-McDonald Asteroid Survey included most of the asteroid belt, and the Palomar-Leiden Survey covered a small section of it but photographed objects ten times as faint. Because no objects associated with asteroids were noted, Gehrels and his colleagues reason, there were no satellites recorded that were 17 kilometers or larger in the case of the complete survey and 3 kilometers or larger in the case of the small-area survey.

Relatively small, distant satellites would thus seem to be scarce or nonexistent; a recent search using the technique of speckle interferometry suggests that close-in companions are difficult to find as well. Otto Franz of Lowell Observatory and Harold McAlister of Georgia State University searched within a few thousand kilometers of about 50 asteroids, including about a dozen of those proposed as possible asteroid pairs. The speckle technique allowed a resolution of 75 kilometers because in it a series of brief exposures captures as points of light the "twinkling" of the asteroid that blurs long-exposure photographs . Mathematical processing restores the image to its undistorted form. This search revealed no companion larger than half the size of its accompanying asteroid.

Gehrels and his colleagues reason that these searches have covered most of the possibilities. Any widely separated companions should have been seen because they would probably not be undetectably small. An asteroid is not likely to hold onto newly created objects of any size recently knocked off it by the collisions that are inevitable in the asteroid belt. On the other hand, any old objects smaller than about 30 kilometers that formed along with the planets are thought to have since been ground up by collisions or knocked out of orbit by an impact.

Small, close-in satellites are not likely either. Under the influence of the tidal forces acting between two bodies, they would crash into the primary asteroid or be pushed well beyond the halo of obscuring light. Large companions can take up stable orbits close to the other member of the pair, but the speckle search would have turned up most of those. These companions would be so large that they would more accurately be said to form a double or binary asteroid.

There are some asteroids that may be such close binaries, perhaps almost touching, that they have escaped telescopic detection. Steven Ostro of the Jet Propulsion Laboratory, Donald Campbell of Arecibo Observatory, and Irwin Shapiro of the Harvard-Smithsonian Center for Astrophysics recently reported that radar observations had revealed some "exotically shaped objects" among the asteroids. Ivar appears to be one object from some angles but possibly two separate bodies when viewed from other angles. Asteroid 1986DA also reflects radar signals the way an extreme dumbbell or two objects nearly touching would. The resolution of the question of binary asteroids will probably only come with the launch of the Space Telescope. ■ RICHARD A. KERR

ADDITIONAL READING

T. Gehrels *et al.*, "The absence of satellites of asteroids," *Icarus* **70**, 257 (1987).