Astronomy

Ron Cowen reports from Houston at the annual Lunar and Planetary Science Conference

Idiosyncrasies of Ida

Imagine dropping a rock from eye level and having to wait 30 seconds for it to hit your feet. That's what would happen if you were standing on the surface of asteroid 243 Ida. Gently toss another rock straight ahead, in the same direction that Ida rotates, and it would land in front of you, as expected. But throw the same rock forward a bit harder, and it would actually double back over your head and strike the surface behind you.

This surprising behavior stems from a combination of Ida's low surface gravity, rapid rotation, and especially its peanut-like shape, which makes the asteroid's gravitational field decidedly irregular. These strange dynamics may explain the placement of a cluster of house-sized boulders on the asteroid, as well as the varied color and reflectivity of its surface, assert Paul Geissler, Jean-Marc Petit, Richard Greenberg, and their colleagues at the University of Arizona in Tucson.

At first glance, the location of the boulders, which the Galileo spacecraft spied when it flew past Ida in August 1993 (SN: 8/6/94, p.93), would seem to pose a puzzle. Scientists believe that the boulders, known as ejecta blocks, are large pieces of Ida's surface shaken loose when a chunk of debris — probably a fragment of another asteroid — slammed into Ida and dug a crater. Because they make easy targets for any other fragment that might strike the asteroid, the boulders won't stay intact long and therefore must be young. However, the only two sizable craters nearby are too old to be the boulders' sources.

In contrast, the impact basin Azzurra, one of the youngest large craters detected on Ida, appears a far more likely candidate and could easily supply the raw material for the boulders. But this crater lies on the opposite face of the asteroid from the boulder concentration. Galileo's flyby only allowed the craft to view one half of the elongated asteroid at high resolution, where the craft saw boulders clustered near the body's leading edge as it tumbles end over end. Azzurra resides along the trailing rotational edge of the other half of the asteroid.

JPL/NASA

Galileo image of Ida shows ejecta blocks (arrow).

Thanks to Ida's weird dynamics, however, this youthful crater may actually reside in the perfect spot to account for the boulders. Using a computer model, Geissler and his collaborators tracked the path of debris thrown upwards by the impact that created Azzurra. They found that many of the higher velocity fragments would loop back, and ultimately settle on the opposite half of the asteroid, closely matching the observed distribution of house-sized boulders.

The simulations also show that a similar distribution of boulders should reside on the asteroid segment that Galileo didn't observe closely.

In contrast to Galileo's brief encounter with Ida, the NEAR craft, scheduled for launch next February, will orbit the near-Earth asteroid 433 Eros for an entire year, beginning in December 1998. Intriguingly, this misshapen asteroid rotates almost as rapidly as Ida, which makes a complete revolution every 4.6 hours. NEAR should determine whether Eros has ejecta blocks on its leading edges, Geissler says.

In their simulation, Geissler and his team also found that finer material excavated from Azzurra would settle closer to the crater, accounting for the brighter, slightly bluer patches in these regions.

Physics

Ivars Peterson reports from San Jose, Calif., at an American Physical Society meeting

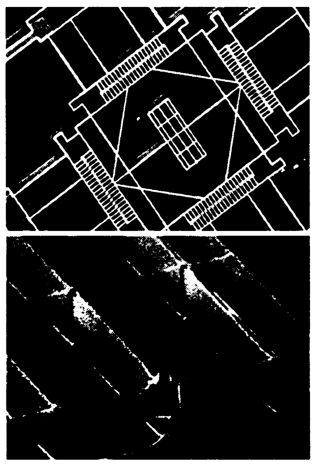
Microtools for scaling nanomountains

The scanning tunneling microscope (STM) has become an essential tool for imaging surface features down to the scale of individual atoms. Typically the size of a fingernail, this instrument has tiny motors to skim a needle's tip back and forth across a surface a few hundred times per second. But such scanning rates are too low for using the apparatus to act as a rapidly responding microsensor, to shove atoms and molecules around efficiently to create patterns for microscopic circuits, or to store massive amounts of data. Reaching a higher scanning rate requires miniaturizing the device further.

Now, after 9 years of effort, researchers have succeeded in fabricating the world's smallest STM by means of the same kind of technology used to manufacture computer chips. "Because it's all done in silicon, everything is integrated," says Noel C. MacDonald of Cornell University. "We now know how to make suspended silicon structures. We know how to make them move in three dimensions. And we can do it on a scale on the order of micrometers."

Occupying a volume only slightly larger than a cubic millimeter, this microelectromechanical STM is driven by "finger" motors, each one only 200 micrometers wide. It can scan as quickly as a million times a second. Though still a long way from commercial use, this tiny device represents a significant step toward the ultimate goal of creating large arrays of these instruments on a single chip.

MacDonald *et al.*/Cornell



Top view of a micro-STM showing four "finger" motors surrounding a rectangular framework that carries the scanning needle (top). Close-up of needle, 5 micrometers tall (bottom).

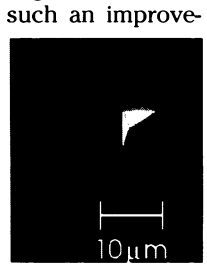
Scratching the surface

In the early days of audio recording, capturing a voice required running a vibrating stylus across the wax surface of a spinning cylinder or disk to create a serrated spiral groove. Replicated in vinyl or some other material, the same groove would cause a needle to vibrate, recreating the original sound.

H. John Mamin and his coworkers at the IBM Almaden Research Center in San Jose, Calif., are pursuing a similar strategy for storing vast amounts of data. Known as thermomechanical recording, this scheme involves focusing brief laser pulses on the tip of a microscopic needle pressed against a spinning disk's surface. The pulses instantly heat the needle, allowing it to sink into the briefly softened plastic to create a chain of tiny, shallow pits.

To make this technique competitive with current data storage methods, the researchers must increase the rate at which a needle can "write" its digital message, going from 100 kilohertz to the megahertz range. Achieving such an improvement requires making the needle and its supporting cantilever as light as possible.

Mamin and his coworkers have now fabricated silicon nitride cantilevers only one-thirtieth the mass of the smallest ones conventionally used in atomic force microscopes. They have used them to "write" and "read" data on disks at rates up to 1.2 megabits per second, bringing the device's performance closer to that of other data storage methods.



L.S. Fan, Mamin/IBM Research

Low-mass cantilever.