Ringing in an estimate of a galaxy's mass

One of the striking manifestations of the ability of massive astronomical bodies, such as galaxies, to act as gravitational lenses and bend the path of light is known as an Einstein ring. This type of circular image results when a massive object with a simple geometry stands perfectly aligned between an observer and a distant light source. Astronomers have now used the characteristics of one such system to estimate the mass of the intervening galaxy, which acts as a gravitational lens.

"This is the most distant galaxy whose mass has been measured," says Glen I. Langston of the National Radio Astronomy Observatory in Charlottesville, Va. "It's also the first time that we've been able to reliably measure the mass of a [gravitational] lens." Langston and his collaborators report their results in the March 1 NATURE.

This particular Einstein ring, designated MG1654+1346, is ideally suited for such a measurement because the lens is simply a single, relatively bright, elliptical galaxy. To produce the Einstein ring, the galaxy magnifies and distorts radio waves traveling from one of two regions of radio-wave emissions that extend out on either side of a more distant quasar.

Because the galaxy itself is invisible at radio wavelengths, astronomers can observe it and the Einstein ring independently. The radio ring consists of a narrow, circular band with two bright, semicircular components. The quasar's second radio-emission region, which is too far from the line of sight to be affected, appears normal.

Knowing the ring's apparent size and the distances to both the background quasar and the intervening galaxy, astronomers can calculate the galaxy's mass. Langston and his colleagues obtain a total galactic mass about 300 billion times the sun's mass. "It's a reasonable number," Langston says. "Our results say that at this distance, which is a reasonable fraction of the observable universe away, galaxies still seem similar to what we see nearby." The results also suggest this galaxy contains a substantial amount of nonluminous matter.

Gravitational lenses can create not only radio rings but also enormous luminous arcs and multiple images (SN: 12/3/88, p.357; 12/9/89, p.375). The study of such images provides a useful probe of the makeup of a variety of celestial bodies.

Gravitational lensing may explain, for example, the puzzling, quasar-like properties of so-called BL Lacertae objects sometimes found embedded in nearby galaxies. In the March 1 NATURE, Jeremiah P. Ostriker of Princeton (N.J.) University and Mario Vietri of the Osservatorio Astrofisico Arcetri in Florence, Italy, cite new astronomical and statistical evidence suggesting that a significant fraction of these bright, compact objects may be the images of more distant quasars substantially amplified by the gravitational effect of individual stars in intervening galaxies that happen to be near Earth.

The result is an optical illusion that puts a bright, compact source of light in the midst of a nearby galaxy. The passage of stars across the line of sight to the quasar could account for the rapid brightness changes typically associated with BL Lacertae objects.

The notion that not only luminous galaxies but also invisible matter could act as gravitational lenses has prompted a number of searches for multiple images and for unusually bright quasars. Such observations could eventually help settle the question of how dark matter is distributed within a galaxy and across the universe (SN: 1/27/90, p.52).

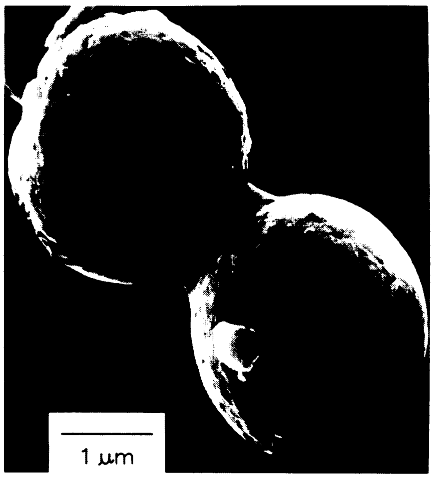
"Rarely in astronomy can such a simple theory as gravitational lensing be applied to such a wide range of observations," writes Daniel W. Weedman of Pennsylvania State University in University Park in a commentary accompanying the research reports. "The bizarre manifestations of these lenses should continue to provide otherwise unobtainable information about dark matter in the Universe."

— I. Peterson

Sonochemistry: The ultrasound and the fury

The scene is downright hellish: Millions of tiny gas bubbles continuously form, grow and implode with such rapidity and force that their contents reach temperatures common at the sun's surface. Shock waves radiating from the miniature depth-charges create localized pressures approaching those of the deepest ocean trench. Hieronymus Bosch would have loved it.

Chemists Kenneth S. Suslick and Stephen J. Doktycz do. Working at the University of Illinois in Urbana-Champaign, they use ultrasound, or sound pitched beyond human hearing, to create these turbulent micro-environments safely within glass vessels filled with solvents and solid particles, in an attempt to solve a puzzle. For years, scientists have wondered why ultrasound accelerates — sometimes up to a millionfold — chemical reactions involving metal catalysts.



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Scanning electron micrograph of zinc particles that fused during high-speed collisions triggered by ultrasonic irradiation.

In the March 2 SCIENCE, Suslick and Doktycz report some details underlying these swift "sonochemical" reactions. "This set of experiments allowed us for the first time to get at least a rough feeling for the conditions that occur when ultrasound irradiates a liquid containing solid powder," Suslick told SCIENCE NEWS.

The ultrasonic shock waves force particles to collide, much as a huge ocean wave might smash two surfers together. By examining fine dissolved particles of transition metals — zinc, tin, nickel, chromium, tungsten and others, which collide and can melt together during ultrasonic irradiation — the researchers have inferred just how fast and hot particle collisions can get.

Tiny metallic "necks" that bridge the fused particles provide the empirical clue for reconstructing the unseen collisions. A neck's volume, ranging from about one-half to six-trillionths of a cubic centimeter, indicates how much metal melts during the collisions and therefore how much energy is needed to drive the melting process. Presumably the particles carried this energy into the collisions in the form of kinetic energy. The researchers calculate that particles with diameters in the 5-to-10-micron range attain velocities ranging from 100 to 500 meters per second.

They also found that metals with melting temperatures below molybdenum's 2,617°C form well-defined necks, while tungsten particles, which melt at 3,410°C show no signs of fusing. Collisions between molybdenum particles result in less-pronounced links, which the researchers describe as "spot welds." They conclude that peak temperatures during interparticle collisions fall between 2,600°C and 3,400°C and that some of the molten necks must cool at rates of more than 1 billion°C per second, since the particles would otherwise separate as they recoil after the collision.

Such findings should help scientists uncover the mechanisms by which ultrasound enhances the catalytic power of metal particles, says sonochemist Philip Boudjouk of North Dakota State University in Fargo.

— I. Amato