Does the mass of an object increase with time?

Since Isaac Newton wrote down his universal theory of gravitation, physicists have believed that mass was a constant quantity. In all their calculations they have assumed that the mass of a given body does not change.

Now two members of the Institute for Theoretical Astronomy at the University of Cambridge in England, Fred Hoyle and J. V. Narlikar, propose a theory in which the mass of one and the same body can vary according to its position in time and space.

Hoyle and Narlikar come to this formulation in order to explain some discrepancies in cosmological redshifts. The reddening of the light from distant galaxies is traditionally interpreted as a Doppler shift caused by their motion away from the observers. The greater the redshift of a galaxy, the greater, theorists supposed, was its velocity and its distance from our own galaxy.

There are, however, a number of instances of bodies that appear to be physically connected yet have significantly different redshifts. This is an inadmissible situation if the velocity-distance relation is the only explanation for redshifts, since bodies that are physically joined have to be going at the same speed. Believers in velocity as the source of redshift have tended to dismiss these cases as projection effects: The bodies are really at different distances; they only appear to be connected.

Hoyle and Narliker declare it is time to take these redshift discrepancies seriously. To accomplish this, they propose, in an article in the Sept. 3 NATURE, a theory in which the mass of a particle can vary according to its location in space-time, and the redshifts depend on mass changes.

Their theory makes the mass of an individual particle dependent on the particle's interaction with all the other particles in the universe. In other words, the mass of the particle is proportional to a mass field generated by all the rest of the universe, and ". . . in general the mass of the particle will not be the same for all points on its path," they write. From the many mathematical possibilities that this leads to they choose one in which the total mass field remains constant in order to make their theory describe the present universe and lead to a formulation that approximates Einstein's general relativity.

These conditions lead to a theory in which the mass of an object increases as time goes on. Since atomic emitters of electromagnetic radiation emit frequencies in proportion to their mass, light from distant bodies will appear redshifted: The emission of hydrogen atoms, say, in a distant galaxy would appear redder than the emission of hydrogen atoms in our own galaxy because the distant emission occurred so much earlier in time.

In this way, without bringing in velocity, Hoyle and Narlikar arrive at the customary relations between redshift, distance and apparent luminosity of celestial objects (which they do not wish to discard) when they consider the universe as homogeneous and smooth over-all. But this theory also allows local variations in the behavior of particle masses that could account for the discrepant redshifts. Connected bodies might have different relationships between mass and time without having to break apart.

The theory also results in a gradual weakening of the force of gravity with time. This would have profound effects on astrophysics and geophysics. One of these is an explanation of continental drift. Continental drift requires strong horizontal forces along the earth's surface, and its proponents have always been embarrassed by the apparent absence of such forces. In the Hoyle-Narlikar theory, weakening gravity makes the radius of the earth increase by 10 kilometers every hundred million years, and the pressure caused by the expansion could generate the horizontal forces. □

Pushing back lunar history to 4.15 billion years

Whether a moon rock is 3.8 billion or 4.3 billion years old may seem an esoteric distinction. But just as on earth, rock-dating is vital to arranging the chronology of lunar history. And the older the rock, the more information it gives about the original chemical conditions and the subsequent differentiation that have led to the present-day earth and moon.

More than 80 rocks were brought back from the Apollo 15 Hadley/Apennine site, originating from at least five different events. Two have now been preliminarily dated by a scientific team, headed by Liaquat Husain, at the State University of New York at Stony Brook.

Rock 15415, the crystalline anorthosite dubbed "Genesis Rock" by the press, is 4.15 billion years old—plus or minus 200 million years. Rock 15555, a basalt named "Great Scott" by scientists, is 3.3 billion years old.

The anorthosite was found perched on a pedestal near Spur crater on the side of Mount Hadley Delta. Because it is an aluminum calcium silicate—believed to be the main constituent of the lunar crust—it has been the source of much scientific excitement (SN: 8/21/71, p. 122). The 3.3 billion-year-old basalt was picked up near the rille that snakes through a mare, Palus Putredinis, a much younger feature.

The age of the basalt is firm. But the 200-million-year margin of error left for the anorthosite will be refined, says Husain. He and John F. Sutter used the Argon 40/39 age-dating to come up with the age span of 3.95 billion to 4.35 billion years for the rock. "This feat was most challenging and elegant," says Leon T. Silver of the California Institute of Technology, who examined the rock in detail before 500 milligrams of it were sent to Stony Brook. The difficulty in dating the rock, says Husain, is that the anorthosite has the lowest content of potassium of any rock yet returned from the moon—100 parts per million, or about one-twentieth of the content of most lunar rocks. The high calcium content also complicates the process, as calcium produces argon 37 and 39.

In any event, says Silver, "this is the most significant sample ever returned from the moon. My prejudice at the time is to say that the 4.15 is the minimum age for this rock." He explains that the anorthosite—like other rocks from the moon—has been modified. It went through at least two fragmental events, and is now a clast out of a larger breccia. The 4.15 could be the date for the last event in its history.

Even more important in Silver's view is that the anorthosite—whose existence after Apollo 11 was merely a theory—pushes back lunar chemical history. Another rock, 12013 from Apollo 12, had complicated it (SN: 5/30/70, p. 528). Unlike 15415, it is an inhomogeneous rock containing some fragments dated at 4.5 billion years. But the rock itself is believed to have crystallized about 4 billion years ago.

Lunar basalts from Apollo 12 dated about 3.3 billion; those from Mare Tranquillitatis, about 3.8 billion. Husain's group will announce next month in SCIENCE that the breccias he has dated from Apollo 14's Fra Mauro site are also about 3.8 billion years old.

The anorthosite may be a link to all these dates. "Very early in lunar history [in the first half-billion years obliterated on the earth], the moon's chemical system was energized to undergo a major chemical change," says Silver. "It is extremely important to know how this chemical differentiation occurs." How the anorthosite relates to the KREEP found in rock 12013 or relates to the mare basalts is a major chemical question. □