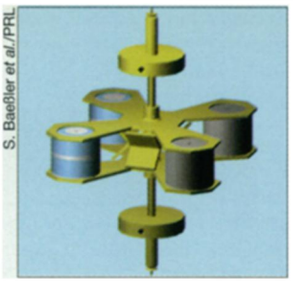
Earth-moon model backs general relativity

Einstein's general theory of relativity predicts that both mass and energy respond to gravity, so even gravity's energy would feel the tug of gravity. Yet, some theories exempt gravitational energy from the force's attraction.

Curious to know which theory is right, physicists in Seattle have conducted new laboratory tests and combined them with findings from previous direct measurements of lunar and Earth motion.



S. Baeßler et al./PRL

The torsion balance, shown in this computer-made image, hangs by a thin fiber in a vacuum. Its rotation would vary if solar gravity tugged differently on moonlike (blue/silver) and Earthlike (gray) masses.

In the Nov. 1 PHYSICAL REVIEW LETTERS, the team at the University of Washington reports that the acceleration of gravitational energy doesn't differ from that of other forms of mass and energy—a finding that supports general relativity. If there's a difference, it must be less than one-tenth of a percent, the researchers say.

"It's a very nice result," comments Clifford M. Will of Washington University in St. Louis. However, gravity specialists weren't "terribly worried" that the accelerations would be different, he notes.

Massive objects convert some mass to energy when forces—electromagnetic, gravitational, and others—draw their parts together. For the rock and dust that coalesced long ago to form Earth, about 460 trillionths of the mass became gravitational energy, scientists have calculated. Only 20 trillionths or so of the matter that formed the moon made the transition.

The Seattle scientists, led by Eric G. Adelberger and Blayne R. Heckel, suspended objects with compositions similar to that of the Earth and of the moon in a rotating torsion balance. That extremely sensitive device detects twisting forces. Adelberger describes the experiment as "dropping a little, tiny Earth and a little, tiny moon toward the sun." The test compares the acceleration of dissimilar materials due to solar gravity.

Einstein's theory holds that gravity accelerates objects equally, regardless of mass, energy, or composition. This notion, called the equivalence principle, has roots reaching back to Sir Isaac Newton, Galileo, and beyond (SN: 9/22/90, p. 183).

General relativity clashes with another major physics theory known as quantum mechanics. Many scientists think that finding a flaw in general relativity, perhaps in the equivalence principle, may lead to a way to reconcile the two theories.

For decades, scientists have been bouncing laser beams from Earth off reflectors on the moon to compare the accelerations of these bodies toward the sun. So far, those investigations have demonstrated equal acceleration of the bodies to a precision of 13 decimal places.

However, the experiments don't distinguish between acceleration due to gravitational energy and that due to other forms of mass and energy, Adelberger notes. A slim possibility exists that two different types of equivalence-principle violation cancel each other.

In that scenario, the bodies' different compositions might tend to make Earth accelerate slightly more rapidly than the moon, while their unequal gravitational energies would lead the moon to accelerate slightly more rapidly than Earth. The result: an illusion that the equivalence principle reigns.

Masses of objects in a laboratory are so small that their gravitational energy is negligible. So the Seattle team set out to cleanly determine whether the composition disparity between Earth and the moon alone affects acceleration. The group used a pair of stainless steel cylinders to mimic Earth with its heavy iron core and a pair of quartz-magnesium cylinders to act as the relatively lightweight moon. Each cylinder weighed 10 grams.

The team found that in their precise measurements, composition caused no difference in acceleration. Consequently, contributions of gravitational energies to accelerations of Earth and the moon, while not directly tested, must also be equal, albeit to lesser precision. *—P. Weiss*

Neandertals show staying power in Europe

As recently as 28,000 years ago, Neandertals lived in central Europe, according to a new study. This indicates that they survived several millennia longer than most scientists have assumed.

The pushed-forward age estimate challenges the view that these heavily built relatives of modern humans took refuge in southwestern Europe shortly before dying out around 30,000 years ago. However, ongoing debate over whether Neandertals contributed significantly to the evolution of modern humans appears unlikely to abate.

Croatian Academy of Sciences

Neandertal jaw from Croatia's Vindija Cave dates to 29,000 years ago.

"I was floored by these new Neandertal dates," says anthropologist Fred H. Smith of Northern Illinois University in DeKalb, a member of the team that derived the age estimates from Neandertal fossils found at Croatia's Vindija Cave. "This adds support to the idea that there was a good deal of genetic exchange between Neandertals and modern humans."

In earlier work, Smith asserted that Neandertal fossils at this site share several anatomical features with modern humans.

The new investigation, published in the Oct. 26 PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES, rests on accelerator mass-spectrometry radiocarbon dating of two Neandertal skull pieces from the cave. This technique measures precise numbers of carbon isotopes in small samples of organic material.

One fossil dates to about 28,000 years ago, the other to 29,000 years ago, Smith and his colleagues report. This evidence for Neandertals' extended European survival indicates that they lived in the same region inhabited by modern humans for at least several thousand years, holds Erik Trinkaus of Washington University in St. Louis, a coauthor of the study. That's plenty of time for extensive interbreeding, Trinkaus argues.

As an example of prehistoric genetic mixing, he cites the recently discovered 24,500-year-old skeleton of a child that—at least in the view of some researchers—exhibits both modern human and Neandertal characteristics (SN: 5/8/99, p. 295).

Moreover, stone and bone tools at Vindija Cave contain some features considered typical of Neandertals and others characteristic of modern humans. Neandertals probably made all of these implements, Smith says, thus challenging the influential theory that modern humans adopted a uniquely advanced tool-making style beginning around 35,000 years ago.

It's also possible, Smith maintains, that Neandertals traded with modern human groups to obtain some of the tools that scientists discovered at Vindija.

Christopher B. Stringer of the Natural History Museum in London finds the Croatian evidence intriguing but still suspects that Neandertals interbred with modern humans just occasionally and only in isolated areas. Cold-adapted Neandertals probably died out due to rapid climate shifts in Europe with which modern humans coped "a bit better," Stringer says.

He also remains skeptical of Smith and Trinkaus' argument that Neandertals fashioned complex tools, such as those uncovered at Vindija, long attributed only to modern humans. *—B. Bower*