Earth Science

Hurricanes within Earth's core

Seismologists made a startling discovery this summer when they found that Earth's inner core spins faster than the rest of the planet (SN: 7/20/96, p. 36). The explanation for these internal gyrations may involve hurricanes of liquid iron swirling in the outer core, a trio of physicists now reports.

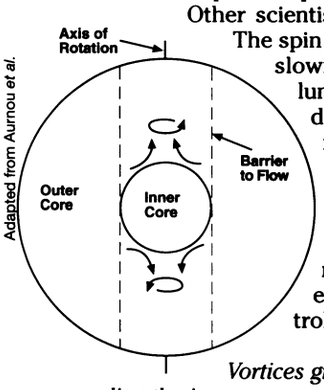
Earth's core consists of two parts, an inner sphere of solid iron and an outer shell of liquid iron alloy. Convection currents that stir the outer core are critical to producing the superfast spin of the inner core, say Jonathan M. Aurnou, Daniel Brito, and Peter L. Olson of Johns Hopkins University in Baltimore.

In the Nov. 15 GEOPHYSICAL RESEARCH LETTERS, the scientists describe a simple theoretical model of the outer core's flow patterns that can explain the inner core's spin. In the model, Earth's rotation segregates the outer core's fluid into two regions separated by a cylindrical barrier enclosing the inner core. Cooler liquid congregates outside the cylinder, and warmer alloy gathers in the polar regions within the cylinder.

Buoyed by its warmth, the fluid inside the cylinder rises and starts to spin like the hot air in tropical storms. "You get what amounts to hurricanelike structures," says Olson.

Rotating faster than the rest of the planet, these vortices of iron-rich fluid generate an electromagnetic field that tugs on the inner core, speeding it up, the scientists suggest. Their model would explain why giant computer simulations also show the core's superfast spin (SN: 10/19/96, p. 250).

Other scientists advocate a different theory. The spin of the entire Earth, they note, is slowing because of friction from lunar tides. It takes time for the deceleration to pass through the fluid outer core, so the inner core's slowdown may lag behind that of the rest of the planet. The Johns Hopkins team finds that the electromagnetic tug is a much stronger effect, however, and should control the inner core's motion.



Adapted from Aurnou *et al.*

Vortices grow inside the cylindrical barrier surrounding the inner core.

Deep-seated shenanigans

Although Earth's inner core is solid iron, it may flow extremely slowly, its insides oozing out over millions of years, according to a new study of earthquake waves passing through the planet's heart.

Barbara Romanowicz and her colleagues at the University of California, Berkeley analyzed seismic data to determine why the core favors vibrations moving parallel to the axis of rotation. Such waves pass through the core faster than those moving in other directions.

Past studies explained the pattern by suggesting that iron crystals in the inner core line up in the preferred direction, causing the core to act as a giant iron crystal. Data from more recent quakes do not support such a simple crystal alignment, the Berkeley scientists report in the Nov. 8 SCIENCE. Instead, their findings point to a more complex crystal pattern that could arise from convection within the solid inner core.

Because of its extreme heat and pressure, the solid iron may be soft enough to flow. According to available data, iron in the center of the inner core appears to flow parallel to the spin axis, much as if the core of an apple were to ooze toward its stem. Once the iron reaches the surface of the inner core, it spreads outward and flows along the surface of the sphere. Eventually, it reaches the opposite pole and dives back inward.

Science & Society

Changing profile for R&D spending

Research and development (R&D) spending in corporate, government, and academic laboratories throughout the United States totals about $170 billion annually. Once the world leader in research, the United States has trailed Japan since 1989 in R&D spending as a share of gross domestic product (GDP). The United States' recent and apparently continuing reductions in R&D as a share of GDP "may be moving us to the 'middle of the pack'" of developed countries, notes Adam B. Jaffe of Brandeis University in Waltham, Mass.

The economist's analysis of U.S. spending, reported in the Nov. 12 PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES (PNAS), finds "that historically our investment in economically relevant R&D has been comparable to other countries' as a fraction of GDP but that we appear to be on a downward trend, while other nations have not, as yet at least, evidenced such a trend." Only on the basis of absolute spending, he notes, does the United States unambiguously lead.

R&D spending as a share of GDP does not account for who performs research or how useful it is—both of which can affect the investment's economic dividends, Jaffe observes. A related study, coauthored by Jaffe and Manuel Trajtenberg of Tel Aviv University and published in the same issue of PNAS, assesses patents, a measure of social and economic dividends from research.

Patents issued to university researchers tend to be more fertile—to spawn more products and innovations—than those issued to corporate scientists, they found. U.S. government patents, in comparison, generally proved "significantly less fertile than corporate patents."

Where is U.S. spending focused? The country spends far less on university scientists than does any other major developed country besides Japan, Jaffe finds. Meanwhile, industry funding has nearly tripled since the 1950s, and at about $100 billion a year, it now accounts for 60 percent of all R&D spending. Though the federal government had for many years been the leading source of R&D money, it now contributes just 35 percent, which, Jaffe notes, comes to "essentially the same [dollar amount] as in 1967."

U.S. schools put off more R&D upgrades

Colleges and universities that conduct research have for years been reporting an urgent need to expand or upgrade their facilities. However, with money tight, many of those repairs or construction projects have been deferred. The value of such postponed projects now totals $9.3 billion, according to the latest biennial survey of U.S. academic research institutions from the National Science Foundation in Arlington, Va.

Although 560 U.S. colleges and universities engage in at least some research or development activities, the leaders—the top 18 percent of those schools—accounted for fully 70 percent of the delayed expenditures.

Roughly 60 percent of the deferments, or $5.7 billion, would have gone to build new research space. New construction of academic research facilities has been declining since 1990. NSF's current assessment indicates that schools found money to begin only one-third of the projects that had been planned for 1994 and 1995. More than half of the money spent on new starts—$2.8 billion—went to build or rebuild research facilities in engineering, medical sciences, and the physical sciences.

While only 17 percent of black college students attend historically black colleges and universities, these schools award 44 percent of the nation's science degrees to black undergraduates. Current spending for new construction of research space in these institutions—$21.3 million during 1994 and 1995—constituted little more than 10 percent of what the schools described as "needed," the NSF survey found.