

Experimental Relativity Hits the Big Time

The turnout for the third "Cambridge" Conference on Relativity was so large that one speaker complained: "I was told that the meeting would just be a few guys standing around a blackboard. Now I see that even the physics press is here." At the meeting, held at the Goddard Institute for Space Studies on 8 June, experimenters discussed measurements of gravity waves, bending of electromagnetic waves by the sun, relativistic time delays and the dragging of an inertial frame by the earth.

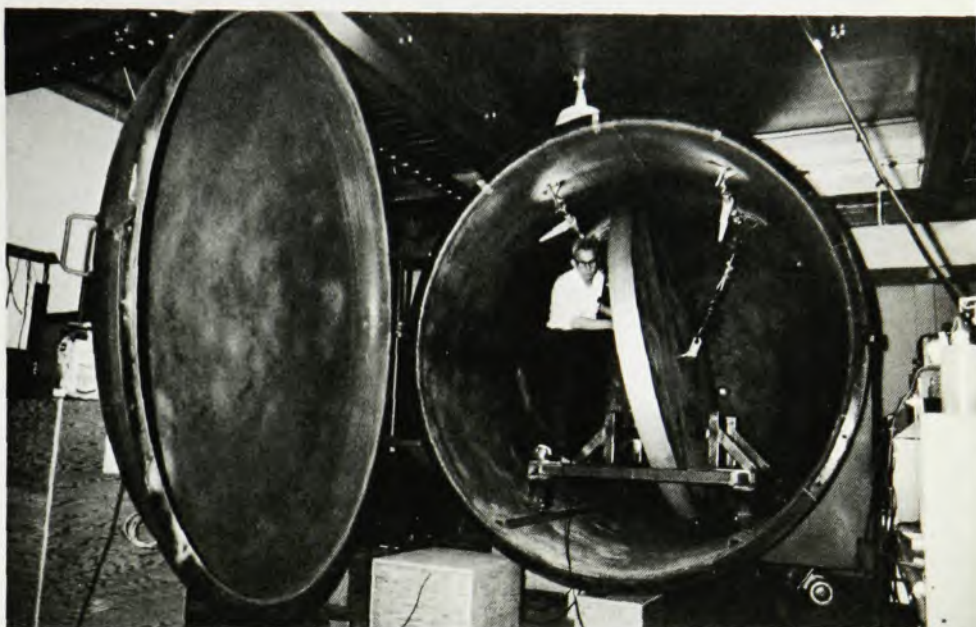
Since Joseph Weber's report last year that he has observed gravitational waves, which he now believes are coming from the center of our galaxy (or 180 deg away from the center), at least ten groups have proposed similar or improved searches for such waves.

Weber himself is now using a disc-shaped antenna to look for a scalar gravitational wave. Such a wave produces stretch in all directions, unlike a tensor wave, which produces a stretch in one transverse direction and a compression in the other transverse direction. The disc's radial mode is at the same frequency as Weber's cylindrical detectors—1661 Hz. The disc, 85 inches in diameter and 6 inches thick, is suspended by an axle passing through its center; piezoelectric crystals in circular patterns near the center are the transducers.

Since the middle of May Weber has been operating the disc at the University of Maryland in coincidence with a cylinder at Argonne National Laboratory and at the same time operating a cylinder at Maryland in coincidence with the Argonne cylinder. In the scalar channel Weber has observed 4 coincidences and in the tensor channel 21. Because 4 accidentals are to be expected, Weber wryly noted: "The scalar channel is not being swamped by gravitational radiation."

Weber is now operating his detectors to look for radiation at 4983 Hz; he says there are good reasons for doubting that he will find any signal. If he does, though, one would have to account for a very broad-band source of radiation of astonishing intensity. Right now all one

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WEBER AND DISC DETECTOR, which he is using to look for a scalar gravitational wave. Disc's radial mode is at same frequency as Weber's cylindrical detectors—1661 Hz. Disc is 85 inches across, 6 inches thick.

Photo of Single Atoms by Electron Microscope

A University of Chicago group using a high-resolution (5-Å) scanning electron microscope believes it has obtained pictures of single atoms of uranium and thorium deposited on a thin carbon substrate. Albert Crewe, Joseph Wall and John Langmore reported (*Science* **168**, 1338, 1970) that by detecting the ratio of elastic to inelastically scattered electrons from the high-Z atoms, they were able to visualize individual atoms. The pictures, displayed on an oscilloscope, show bright spots in the kinds of locations expected by the experimenters. Because of the limitation of the 5-Å resolving power, the Chicago group constructed various molecules containing heavy atoms spaced further apart than 5 Å.

The Chicago microscope has a field-emission source that produces a focused spot about 5 Å in diameter; the electron current is 10^{-11} to 10^{-10} amperes, and the beam convergence angle is about 20 milliradians. Because the elastically-scattered electrons have large scattering angles and the inelastics have small

scattering angles, one can pick up an appreciable portion of the elastics with an annular-shaped detector below the sample. Those electrons that pass through the hole in the detector enter an energy-analyzing spectrometer, which separates out the inelastics. The ratio of elastic to inelastic is then displayed on the oscilloscope.

The sample-preparation technique that made the Chicago work possible was developed several years ago by Michael Beer (Johns Hopkins University). In one experiment the Chicago experimenters made a uranium compound in which two uranium atoms were expected to be symmetrically arranged, separated by about 13 Å. The compound was sprayed onto clean carbon and then scanned. Pairs of bright spots were seen, which disappeared when only the inelastic signal was applied to the oscilloscope. The group found a variation in spot spacing consistent with their ideas of the compound's molecular structure.

Similarly, the experimenters made a thorium polymer, sprayed it onto clean



CHAIN OF THORIUM ATOMS is believed to be visualized in this electron micrograph made by Albert Crewe and his collaborators. The group coated a thin carbon film with a dilute solution of thorium nitrate reacted with benzene tetracarboxylic acid. It was expected that long chains of thorium atoms would be formed separated by 13 Å, 23 Å, and so on, according to the degree of polymerization of carboxylic acid between thorium atoms. Strings of white spots are presumably thorium atoms. Photo width represents 670 Å.

carbon, scanned the sample and observed long chains, as expected (see photograph). Again the average spot spacing was about 13 Å.

Crewe believes his technique will be applicable to a wide range of biological materials because a variety of heavy-atom stains have already been developed for x-ray crystallography. He hopes now to use the stains for noncrystalline materials such as DNA. The most exciting challenge to Crewe now is the possibility of finding the base sequence of DNA.

At Johns Hopkins, Beer has been trying for many years to find different heavy-metal tags for each of the four DNA bases. He has been using conventional transmission electron microscopy.

It has been found that a certain osmium salt ($Z = 76$) can be attached to thymine, for example. If you know that the osmium always binds to one particular repeating site, then it would be much easier to follow the chain. Applying the field-emission scanning microscope technique one would see bright spots at each of the thymine locations, and nothing in between.

With a new microscope scheduled for completion next year Crewe believes the resolution will be small enough (2 or 3 Å)

to visualize atoms with Z as low as 40.

The problem of visualizing atoms with lower atomic numbers will not be automatically solved by improving the microscope resolution. Lowering Z increases the probability of ionization; so the molecular structure is more likely to be affected. With heavy atoms such as uranium, Crewe says, even if a molecular bond is broken the uranium would not move very far because of its mass (although he told us he occasionally has seen one of his spots move or two spots close together merge into one). Also, smaller Z makes it tough to achieve sufficient contrast.

At least one experimenter (Leonard Ornstein of New York's Mount Sinai Graduate School) has questioned whether or not Crewe has actually visualized single atoms, although he does grant that Crewe may have seen clusters.

The first photographs of individual atoms were made by Erwin Muller in 1957. He produced pictures in which one could see individual platinum and tungsten atoms on the surface of a field-emission source. Many observers believe that the field-emission microscope technique would not work for biological specimens.

Heavy-Ion Accelerators Built In Germany, France, US, USSR

A heavy-ion accelerator called "UNILAC" is to be built just outside Darmstadt, West Germany. The accelerator is expected to accelerate uranium ions to nearly 12 MeV/nucleon and lighter ions as high as 20 MeV/nucleon. The project has been authorized and funded by the German government for \$22 million, and the scheduled completion date is 1974 or 1975.

The accelerator will consist of three linacs: The first stage is a coaxial Sloan-Lawrence design and will accelerate particles to energies below 1 MeV/nucleon. The second stage, which will consist of up to 70 1-meter-long helical accelerator modules, will boost the ions up to at least 6 MeV/nucleon. In the third stage, consisting of 20 meters of single resonators, ions will be accelerated to their final energy. This design will allow continuous energy variation for the beam. There will be four separate ion sources, two Penning and two duoplasmatron. Uranium ion intensities up to 3×10^{12} ions/sec are expected, with still higher fluxes for lower-mass projectiles.

ALICE, a linac-injected cyclotron at Orsay, France, produced the world's first usable "superheavy" ion beam in April, a high-quality nanoamp beam of 440-MeV Kr^{22+} . Because the ion source was running at only 1% of the conservative design estimate, a considerable increase in flux is expected shortly. ALICE is expected to accelerate ions as high as $A = 100$ to energies of 4 MeV/nucleon, with lower- A projectiles up to 10 MeV/nucleon. Experiments to search for new superheavy elements have begun.

The Berkeley super-HILAC, which has two Alvarez linac sections, is designed to accelerate all ions up to uranium to about 8 MeV/nucleon. Construction is expected to end in mid-1971. The device is expected to yield up to 10^{12} ions/sec.

The rebuilding of the Dubna 310-cm cyclotron, which is being converted into a 4-meter isochronous cyclotron, is scheduled for completion in 1972. Xenon beams of 10^{11} ions/sec at 4 MeV/nucleon are expected. An 8-meter heavy-ion cyclotron is reportedly being designed by the Dubna group, too.

IN BRIEF

Mercury appears to have continent-sized rough spots along its equator, according to Richard Goldstein of Cal Tech's Jet Propulsion Laboratory.