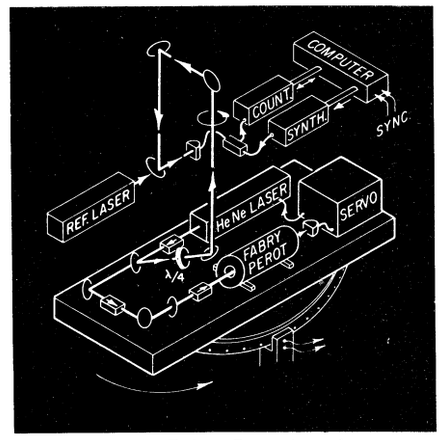
The Expanding Universe:

Looking for a Stretch on the Bias

The expanding universe has been compared to a rising dough, but is it yeastier in one direction than the other? An experiment in the tradition of Michelson and Morley seeks a preferred direction of stretch as they sought a preferred direction of velocity.

BY DIETRICK E. THOMSEN



Phys. Rev. Letters/Brillet and Hall

The length of a Fabry-Perot interferometer determines the frequency of the light that will form a standing wave between its mirrors. The servo forces the HeNe laser to run on that frequency, and its value is read out by mixing the diverted part of the HeNe beam with the beam from the reference laser.

For centuries the scientists and philosophers of mechanics have been divided into two factions, the absolutists and the relativists. The absolutists say that there is a certain physical frame of reference that represents a state of absolute rest for the universe as a whole. Against this any motion could be measured absolutely. The relativist point of view is that there is no absolute standard of rest. Motion can be measured only with reference to other motion. All frames of reference are equal. None is privileged.

In the last hundred years the relativists have taken over the preeminence that the absolutists had held for most of the modern period. The process began with the famous "aether drift" experiment of Michelson and Morley. Out of that grew special relativity, which proclaims the equivalence of all unaccelerated frames of reference. Einstein generalized that to include accelerated frames as well. That is, bodies under the influence of forces were brought under the relativistic arcanum along with those that were not. The result has been a total revolution in our views of space, time, force, mass and energy. Everything from cosmology to particle physics belongs to the relativist point of view. So why do they keep setting up new aether drift experiments? Just for that.

We have seen new aether drift experiments in the air and on the housetops. Now we see one on the ground at the Joint Institute for Laboratory Astrophysics in Boulder, Colo. In the Feb. 26 PHYSICAL REVIEW LETTERS A. Brillet and J. L. Hall of that institution report on a modern version of the Michelson and Morley experiment that they say refines the result of a similar trial made 15 years ago by a factor of 4,000.

The luminiferous aether had been proposed when it became clear that light was a wave. A wave needed a carrier, and the strangely self-contradictory properties assigned to the aether were less troublesome than no carrier at all, so everyone believed in the aether. Since the aether filled the whole universe, it became clear that to be at rest with the aether was to be at rest in the universe.

Maxwell's theory of electromagnetism, which supplied a finite speed for light, and Michelson's proven ability to measure that speed gave the chance to measure the earth's absolute motion against the aether. What Michelson and Morley did was to measure the velocity of light in various directions and compare them with one another. If the earth was drifting through the aether, the speed and direction could be calculated from those comparisons.

The surprising result was that there were no differences. Light has the same speed in all frames of reference. The conclusion that eventually emerged from this was that there is no absolute rest; all frames of reference are philosophically equivalent. Applied to reference frames moving uniformly (called inertial frames) the idea produced the weird world in which mass is not constant and velocity has a speed limit. The transformation laws of special relativity, the laws that translate a velocity from one reference frame to another, do not work if one of the frames is accelerated, if it is under the influence of a force. In general relativity Einstein solved this problem, and in doing so turned force, that is, gravity, into an aspect of geometry, a manifestation of the curvature of space.

Einstein thus brought curvable, malleable space into physics, and modern searches for "aether drift" take off from there. Michelson and Morley were looking for an absolute velocity. The cosmology of their day believed in a static universe that was essentially at rest, and they were looking for the standard of rest. We believe today in an expanding universe. This means that space itself is expanding. If the objects embedded in that space — galaxies, quasars, the earth particularly — have a motion above and beyond that expansion, they can be said to be moving with respect to the universe as a whole.

Modern "aether drift" experiments look for such a motion, and there is some indication that there is one. If it exists, it is not a motion against a standard of absolute philosophical and theological stasis such as people in the late 19th century believed in. It is a motion against a "rest" that is itself dynamic. And so one must ask whether "rest" is the same everywhere. Is space isotropic? It is a question not heard in Michelson and Morley's day.

Given that space is stretchable, is it necessarily being stretched the same in all directions? Most modern cosmologies are built on the assumption that it is, and mechanics has always been based on the proposition that if you have a motion going, it will follow the same law no matter what direction it goes.

Michelson and Morley were trying to find differences in speed by observing the interference between two reflected beams of light as the path of the light was rotated through various directions. Changes in speed would change the phase relation between the beams and so the interference. The Brillet-Hall experiment is designed to find changes in the length of an object as it is rotated around a circle. Such a change might appear due to the extra stretch of space in some direction.

The object of the test is a Fabry-Perot interferometer, a light-reflecting device commonly used to set up length standards. Light from a helium-neon laser is put through the Fabry-Perot and then fed to a servomechanism that drives the laser. The servo system locks the laser to the frequency coming through the Fabry-Perot so that the laser operates on the frequency that forms a standing wave between the Fabry-Perot's mirrors. If the length of the Fabry-Perot changes, the standing wave frequency will change, and the change can be read out by heterodyning a portion of the laser's power with another very stable laser.

The result of the tests reported is quite null. There is no indication of an anisotropic direction in space. At the end Brillet and Hall mention an interest in devising yet more precise tests of minute general relativistic anomalies. □