

500-fold reduction in each stage, and reached at least 10^{-6} G. (His magnetometer was not sensitive to fields lower than that.)

Nuclear gyroscope. Fairbank and Hamilton want to use their zero-field apparatus to do two experiments on the gyroscopic behavior of He^3 nuclei. By mixing 0.001% He^3 with He^4 one can extend the He^3 inherent relaxation time from 500 sec in pure liquid He^3 to 1 year in the solution. Then one can polarize the He^3 nuclei and see their precession.

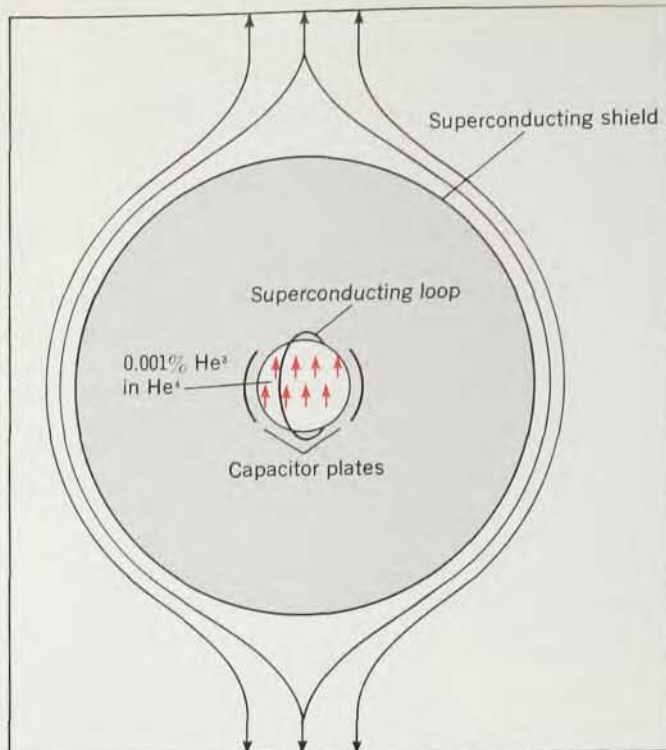
The apparatus (see figure) consists of a 30-cm-diameter quartz ball containing a small sample of polarized He^3 in a He^4 solution. The ball is coated with a superconducting magnetic shield from which the last quantum of magnetic flux will have been excluded, thus giving zero magnetic field inside. An electric field will be applied to the sample, which will cause the He^3 nucleus to move off center in the atom. If the He^3 has a permanent electric dipole moment the electric-field gradient in the atom will cause the nucleus to precess. A superconducting loop surrounding the He^3 forms part of a magnetometer to measure the precession.

Fairbank and Hamilton hope that the same apparatus will one day be good enough to try an earthbound check on general relativity. He would use the He^3 nucleus as a free-precession gyroscope inside the zero-magnetic-field apparatus, where it would be unaffected by external torques, and see how its orientation changed over the course of one year. —GBL

Tunable Infrared Source Yields Continuous Output

A team at Bell Labs has made a continuous parametric oscillator, tunable over a wide frequency range, with a barium-sodium niobate crystal as the nonlinear medium. The work is reported by Richard Smith, Joseph Geusic, Hyman Levinstein, Jerry Rubin, Shobha Singh and Lagrande van Uitert in *Appl. Phys. Letters*, 1 May.

The output of the device is continuous, coherent infrared radiation, tunable (in principle) from 0.65- to 4-micron wavelength. In this frequency range, devoid of monochromatic sources until recently, lasers have coherent output but are not tunable, and



FREE-PRECESSION NUCLEAR GYROSCOPE will be operated in zero field to look for He^3 electric dipole moment.

earlier forms of parametric oscillator provided a pulsed, rather than continuous, output. A parametric oscillator accepts an input at one frequency (the "pump") and provides an output at another (whereas an ordinary oscillator converts dc to ac). The first tunable parametric oscillators used lithium niobate as the nonlinear oscillator element, and because of this material's property of suffering optically induced refractive-index changes it could only be operated in a pulsed mode.

The new material, $\text{Ba}_2\text{NaNb}_5\text{O}_{15}$ (known in the trade as "banana"), which was developed at Bell Labs by Geusic, Levinstein, Rubin, Singh and van Uitert, can be operated continuously without adverse optically induced refractive-index effects ("optical damage") such as has been observed in other highly nonlinear material such as LiNbO_3 . On account of its optical nonlinearity it was first employed as a harmonic generator for laser light; the output from a 1.064- μ infrared YAG-Nd laser emerges from a crystal of this material as green 0.532- μ -wavelength light.

In the new parametric oscillator two $\text{Ba}_2\text{NaNb}_5\text{O}_{15}$ crystals are used. The first, 3mm long, is inside the cavity of a YAG-Nd laser, and the second-harmonic output at 0.532- μ becomes the

pump power for a second crystal, 5 mm long. This oscillator crystal lies in an optical cavity formed by one face of the crystal and a curved mirror. The pump power required to sustain parametric oscillation is 45 mW and is spread among 15 modes, for an average of 3mW per mode at threshold. When pumped with 300 mW, the output from both ends of the oscillator is 3 mW, so the overall efficiency is 1%.

The oscillator can be tuned by variation of its temperature. In the device as reported, temperature variation from 97° to 103°C gives a wavelength range .98–1.06 μ , but further variation is limited by the transmission factor of the mirrors; suitable choice of mirrors should make possible a 0.65–4- μ -frequency range.

Output from the prototype consists of spikes, each of a few microseconds duration, probably resulting from variations in the pump frequency and mode jumping. Stabilization to better than 5×10^{-8} should give continuous output in any particular mode. —JTS

Close Icarus Approach Tests Mercury Mass, Perihelion Shift

The asteroid Icarus (PHYSICS TODAY, October 1965, page 94) will be under close optical and radar scrutiny when it swings to within 6.36 million km of