A Ground Motion Sensing Triangular Laser 51 m in Perimeter

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ABSTRACT

Since the early 1960's when it was first shown that ring lasers could detect rotation, small navigational ring laser gyroscopes have become commonplace. More recently, large perimeter ring lasers have been developed for geophysical applications. In active ring laser gyroscopes, coherent waves of light are simultaneously propagated around the laser cavity in both a clockwise and counter clockwise direction. If the laser cavity is rotating, the time required for light to complete a path around the cavity depends on the direction of propagation. This small difference in transit time creates a frequency difference between the counter propagating waves that is proportional to the rotation rate. A small amount of light from each of the counter-propagating waves is transmitted through one of the dielectric mirrors and is collimated and combined on a detector; the beat or Sagnac frequency produced by the rotation of the Earth in such an arrangement is given by $\Delta f = 4A\mathbf{n}\cdot\mathbf{\Omega}/\lambda p$. In this relation, Δf is the beat frequency, A is the area of the laser cavity, p is the perimeter of the cavity, λ is the laser's wavelength, and $\mathbf{\Omega}$ is the angular frequency of rotation. The symbol $\mathbf{n}$ represents the normal to the ring laser cavity, and the expression $\mathbf{n}\cdot\mathbf{\Omega}$ gives the projection of the normal on the rotation axis of the earth.

The 51 m perimeter ring laser produces a beat frequency due to Earth's rotation of ~776 Hz. Geophysical phenomena that perturb the laser's geometry or its orientation will slightly change the beat frequency. Beat frequency changes introduced by variations in the angle between the normal to the laser and the Earth's axis of rotation allow the detection of phenomena such as Earth's polar motion, solid earth tides, and variations in local tilt. Ring laser gyroscopes are particularly sensitive to rotation about the normal to the ring laser cavity; this allows the routine detection of the rotational components of seismic and teleseismic waves. To facilitate analyzing the rotational components, the installation of a conventional seismograph at the laser site is planned. Although the ring laser is located ~600 km from the Gulf of Mexico, pronounced periodic responses were detected due to hurricane activity in the Gulf of Mexico. In addition to the ubiquitous microseisms, frequencies in the 8 mHz range were detected. Similar frequencies are observed in the vertical record of conventional seismographs even on seismically quite days. The seismographic record apparently reflects vibrations associated with the fundamental spheriodal modes of the Earth. The source of the 8 mHz signals in the ring laser is less clear. Selected examples of various ground motion measurements made by the ring laser will be presented in the poster session.