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Pulsed fiber optics lasers as highly sensitive sensors

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An interferometer or resonator is a device in which optical beams of specific frequencies circulate with minimal losses. These losses are completely compensated by the gain inside a laser resonator. A small perturbation introduced inside the laser can affect its frequency, which in turns becomes a metric of that perturbation. The perturbation is usually caused by an electric or magnetic field, rotation, acceleration, nonlinear index of refraction etc. Tiny changes of optical frequency are monitored by superimposing the laser field and a reference field (from the same laser) on a detector. This technique requires creating a laser in which two beams - reference and sample beam - circulate independently. This can only be achieved with ultrashort pulses that do not occupy the same position in space at the same time. Another requirement is that the intracavity laser beams be “shielded” from the outside world, except where the sample beam has to interact with the quantity to be measured. Fiber lasers are ideal in this respect, since the beam is totally shielded from its surroundings. In our fiber laser, two ultrashort pulses circulate in opposite directions, and are extracted from the laser loop to interfere on a detector. As the loop rotates, the detector sees one sense of circulation Doppler shifted up, and the other direction Doppler shifted down, resulting in a “beat note” proportional to the rotation rate. In the measurement below, the rotation rate of the earth is dwarfed by a large beat frequency due to the nonlinear index of the fiber, and the fact that the laser cavity is not perfectly symmetric.