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Rotational seismic detection through G-Pisa ring laser gyroscope

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A ring laser gyroscope with 1.35 m of side, named "G-Pisa", has been installed inside the central area of Virgo gravitational waves interferometer, with the specific goal of collecting high-sensitivity measurements of ground rotations. The instrument operated almost continuously from July 2010 through September 2011. The apparatus was designed to provide a very low mechanical and thermal drift of the ring cavity geometry and is conceived to be operative in two different orientations of the laser plane, in order to detect rotations around either the vertical or the horizontal direction. The mechanical design of the instrument and its main characteristics will be described, and we will present its measured sensitivity limit. We show that the stability of the sensor above 10 s of integration time is mainly limited by backscattering effects, and it can be improved by off-line analysis, applying a simple effective model for the laser action.

During the period of operation of the gyroscope, many earthquakes were observed, at both regional teleseismic distances. In particular, with the laser gyroscope operating in a vertical plane (thus detecting rotations around the horizontal axis), we observed the ground rotations associated with the Mw = 9.0, 11th of March 2011, Japan earthquake. Comparison of ground rotation speed with vertical accelerations from a co-located force-balance accelerometer shows excellent ring laser coupling at periods longer than 100s. Under the plane wave assumption, we derive a theoretical relationship between horizontal rotation and vertical acceleration for Rayleigh waves. However, due to the oblique mounting of the gyroscope with respect to the wave direction of arrival, apparent velocities derived from the acceleration / rotation rate ratio are expected to be always larger than, or equal to, the true wave propagation velocity. This hypothesis is confirmed through comparison with fundamental mode, Rayleigh wave phase velocities, predicted for a standard Earth model.