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Rotational ground motions: a new observable for seismology?

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It has been noted by theoretical seismologists for decades that - in addition to translations and strains - the rotational part of ground motions should also be recorded. It is expected that collocated measurements of translations and rotations may (1) allow restitution of seismograms to the complete ground motion of an observation point; (2) help to further constrain rupture processes; (3) provide additional hazard-relevant information to earthquake engineers. The lack of instrumental resolution used to be the main obstacle to observing rotational motions. Recently, ring laser technology has provided the means to develop instruments that allow the observation of rotational motions in a wide frequency band and epicentral distance range. We report observations of rotations around a vertical axis of several large earthquakes obtained by a 4x4m ring laser installed in SE-Germany and compare them to broadband translations. Assuming plane transverse wave propagation (e.g. Love waves), rotation rate and acceleration should be in phase and amplitudes scale linearly with the horizontal phase velocity. This implies that - in principle - collocated measurements of translations and rotations would allow estimation of Love-wave dispersion and thus provide additional information not contained in classical three-component recordings. By comparing the observations with complete 3D global synthetic seismograms we show that the phase and amplitudes of the rotational observations are consistent with the translations and that there is a good match between observed and modelled Love-wave phase velocities. The development of a prototype ring-laser based instrument specifically designed for seismology has been completed and is installed since early 2005 at Pinon Flat observatory in Southern California for testing. We will report preliminary observations.