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Towards A Global Network Of Rotation Sensors

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Summary

Currently there are three operating rotational sensors world-wide with sufficient sensitivity to be useful in broadband seismology.

These are (1) Wettzell, Germany;
(2) Christchurch, New Zealand;
(3) Pinon-Flat Observatory, California.

At present, there are severe obstacles to efficiently visualize, process and analyze the incoming data compared to the well established standards in seismic networks. The aim of this project is to introduce data formats, transfer protocols, and a data base structure that allows near-real time investigation and easy rapid post-processing of event (and continuous) data from those sensors. These sites are also used as an example of the more and more common multi-component observations that require adaptation of common data exchange formats and the development of appropriate processing tools that can exploit the additional possibilities of the various collocated sensor technologies. This infrastructure shall be used to investigate the quality of observations at the various sites and whether the observations are compatible with each other and the collocated observations of translations with standard seismometers. Here we present the setups at each site and show data examples.

(1) Fundamental station Wettzell, **Germany**

"G" is resting on a granite table embedded in a 90t concrete monument, which is attached to a concrete pillar, founded on crystalline bedrock, 10m below the surface. It is a semi-monolithic construction of Zerodur, which has a very low coefficient of thermal expansion ($1.4 \cdot 10^{-8}\ K^{-1}$). Its size is exactly 4 x 4 meters.

G Ring laser (Grossring) facts:

- coordinates: latitude 49,145; longitude 12,878
- operational since 10/2001
- Seismometer: STS-2 (WET)
- Acquisition of high-sampling rate rotation rate (e.g., 20Hz) needs to be improved.

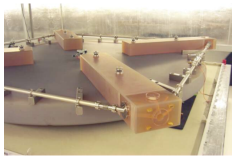

fig.2: Ring laser "G", Wettzell, Germany

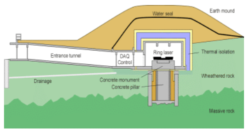

fig.3: plan of Ring laser vault

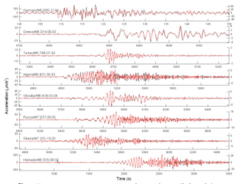

fig.5: transverse acceleration (black) vs. rotation rate (red) at WET for events of various epicentral distances (Igel et al., 06)

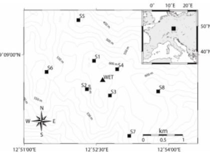

fig.4: Seismic array to determine rotations from translations

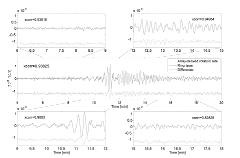

fig.6: Array-derived vs. ring laser rotations (difference in gray, Suryanto et al., 2006)

(2) Cashmere Cavern, **Christchurch, New Zealand**

There are currently 4 Ring lasers located at Christchurch, New Zealand.

Three of these instruments (C-I, C-II, UG-II) are able to measure rotation around a vertical axis, G-0 measures rotation around a horizontal axis. The Ring lasers are located inside an old WW-II bunker.

- coordinates: latitude -43,5769; longitude 172,6222
- Observatory operational since late nineties
- Data from Christchurch not yet systematically analyzed, only system that would allow measuring "true" tilt!

fig.7: Ultra-G I, cashmere cavern, Christchurch

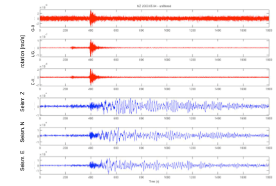

fig.8: raw data from Ring lasers and a seismometer. Top: 3C rotations(G0, UG, CII) , bottom 3C seismometers

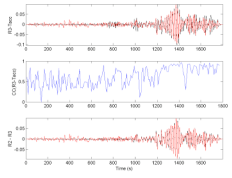

fig.9: Top: transverse acceleration (black) vs. rotation rate (red). Middle: correlation coefficient in sliding time window. Bottom: CII vs UGII.

(3) Pin on Flat Observatory, **Pinon Flat, California**

The Geosensor is located at a the Pin on Flat geophysical observatory of UC San Diego north-west of San Diego.

Geosensor facts:

- coordinates: latitude: 33.6090
  longitude: -116.4553
- deployed in 2005
- seismometer: Lennartz LE-3D 20s at PFO

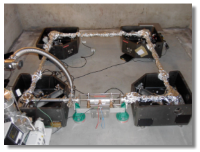

fig.10: Geosensor in test phase

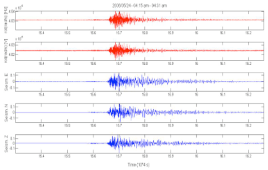

fig.11: Red: two different acquisition systems for rotations: Blue three translations.

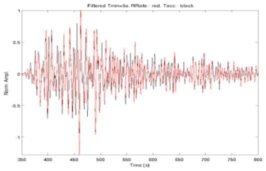

fig.12: transverse acceleration vs. rotation of event shown in fig. 9.

fig.1: Ring laser locations

Future

- At present it is difficult to perform comparative studies of the various sites due to the heterogeneous infrastructure. Therefore we intend to install common acquisition systems (Quanterra) to standardize data formats and obtain similar standards than in broadband seismology.
- A new web-based data archive structure is currently being developed with a specific aim to allow for multi-component seismic data.
- A data flow from all ring laser locations into a central archive shall be setup with near realtime data access and data visualization.

Publications with data from the ring laser systems.

Cochard, A., Igel, H., Schuberth, B., Suryanto, W., Velikoseltsev, A., Schreiber, U., Wassermann, J., Scherbaum, F., Vollmer, D. Rotational motions in seismology: theory, observations, simulation, in "*Earthquake source asymmetry, structural media and rotation effects*" eds. Teisseyre et al., Springer Verlag (2006).
Igel, H., Schreiber, K.U., Flaws, A., Schuberth, B., Velikoseltsev, A., Cochard, A., Rotational motions induced by the M8.1 Tokachi-oki earthquake, September 25, 2003, *Geophys. Res. Lett.*, 32, L08309, doi:10.1029/2004GL022336 (2005).
Igel, H., A. Cochard, J. Wassermann, A. Flaws, U. Schreiber, A. Velikoseltsev, and N. Pham Dinh (2006,) Broad-band observations of earthquake-induced rotational ground motions, Geophys. J. Int., in print.
McLeod, D.P., Stedman, G.E., Webb, T.H. & Schreiber, U. Comparison of standard and ring laser rotational seismograms. *Bull. Seis. Soc. Amer.* 88, 1495-1503 (1998).
Pancha, A., Webb, T.H., Stedman, G.E., McLeod, D.P. & Schreiber, U. Ring laser detection of rotations from teleseismic waves. *Geophys. Res. Lett.* 27, 3553-3556 (2000).
Schreiber, K.U., Klügel, T. & Stedman, G.E., Earth tide and tilt detection by a ring laser gyroscope. *J. Geophys. Res.* 108, No. B2, 10.1029/2001JB000569 (2003).
Schreiber, U., Stedman, G.E., Igel, H., Flaws, A. Ring laser gyroscopes as rotation sensors for seismic wave studies. In "*Earthquake source asymmetry, structural media and rotation effects*" eds. Teisseyre et al., Springer Verlag (2006).
Stedman, G.E. Ring laser tests of fundamental physics and geophysics. *Reports Progr. Phys.* 60, 615-688 (1997).
Suryanto, W., Igel. H., Wassermann, J., Cochard, A., Schuberth, B., Vollmer, D., Scherbaum, F., Schreiber, U., Velikoseltsev, A. First comparison of array-derived rotational ground motions with direct ring laser measurements, Bull. Seis. Soc. Amer., in print (2006).