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Advances in inertial Earth rotation measurements – new data from the Wettzell G ring laser

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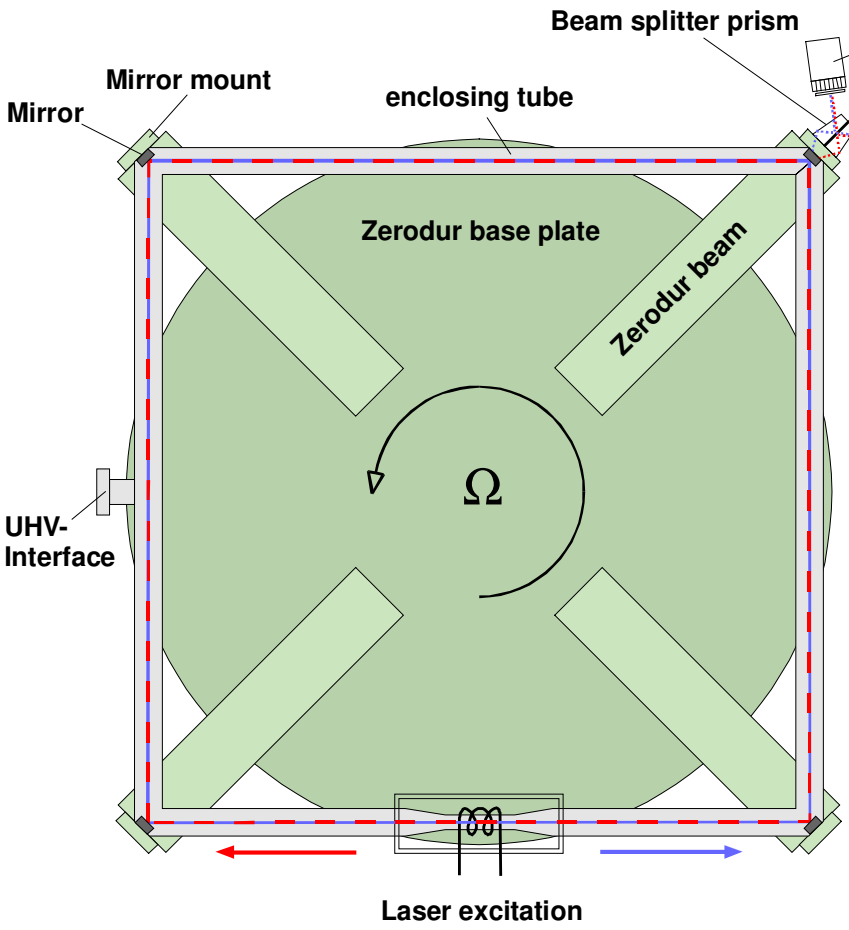
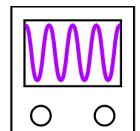
Benefits of Ring Laser Measurements

- Complementary measurements to geodetic space techniques
  - completely different type of measurement
  - high temporal resolution (subdaily variations)
  - continuous operation, real time availability
  - no network required
- Direct access to polar motion
  - Ring lasers are sensitive to motions of the rotation axis with respect so the Earth
  - They are not sensitive to motions of the rotation axis in space

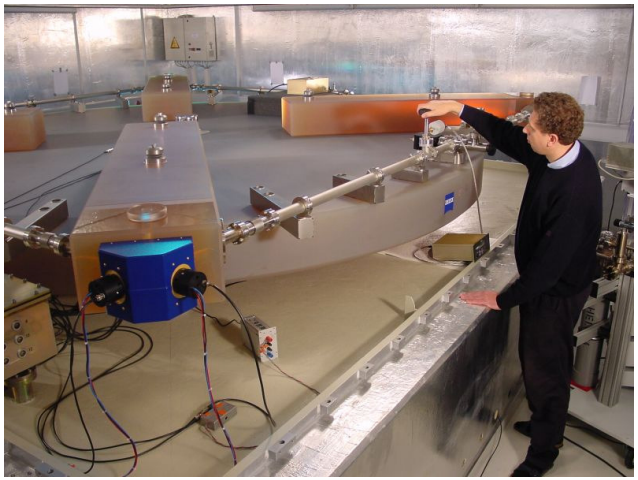
The Wettzell "G" Ring Laser





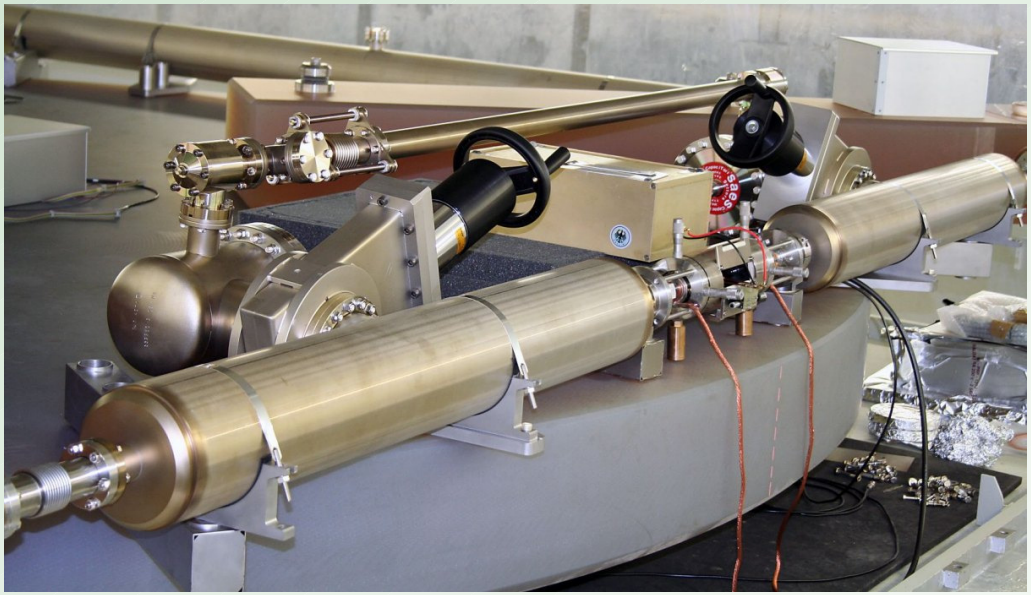
Sagnac formula

$$\Delta f = \frac{4A}{\lambda L}\,\vec{n}\cdot\vec{\Omega}$$



Modifications in 2006

- Improvement of the vacuum system
  - Stability of the Sagnac frequency suffered from outgassing of impurities (H_2, H_2O) from the stainless steel surfaces
  - Replacement of the old 50 mm tubes by 150 mm tubes
  - Installation of a getter tank to catch gas impurities



- Replacement of a Rb frequency standard by a reference frequency coming from a hydrogen maser

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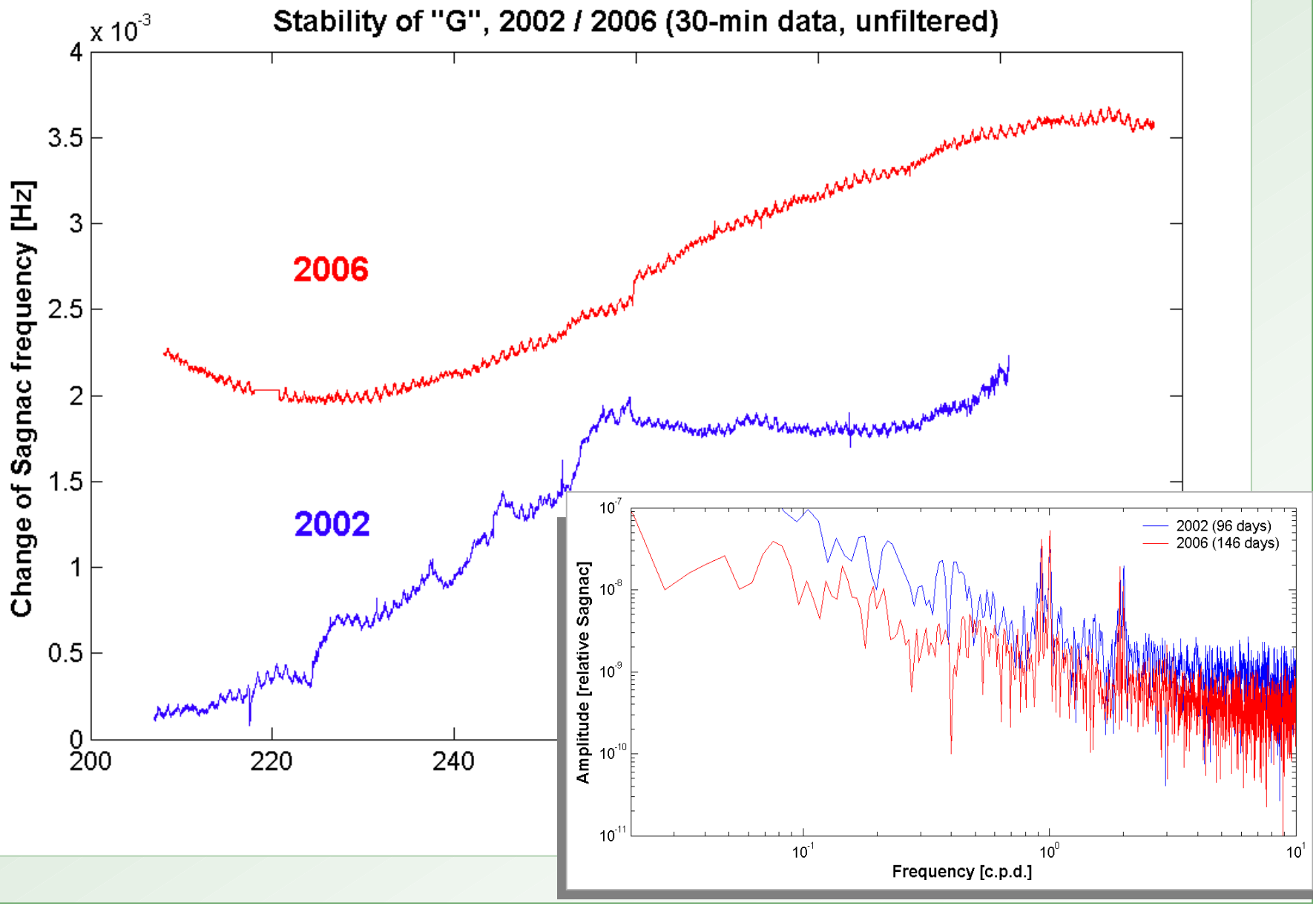
New Time Series



Data processing

- Data acquisition: frequency counter integrating over 30 min
- Removing outliers, resampling (30 min)
- Correction for local tilts
  - tiltmeters on top of the ring laser (< 0.1 mas)
  - correction for tidal attraction and thermal effects
- Correction for instrumental effects
  - pressure-induced temperature variations
- Correction for diurnal polar motion (optional)
  - 21 biggest terms from Brzezinski (1986)
- Spectral analysis
  - Multiple fourier transformations → increase frequency resolution
- Amplitude estimation of diurnal polar motion terms
  - Matlab least square fit / fourier type
  - Bernese 5.0 (ERPEST)
  - Eterna 3.4

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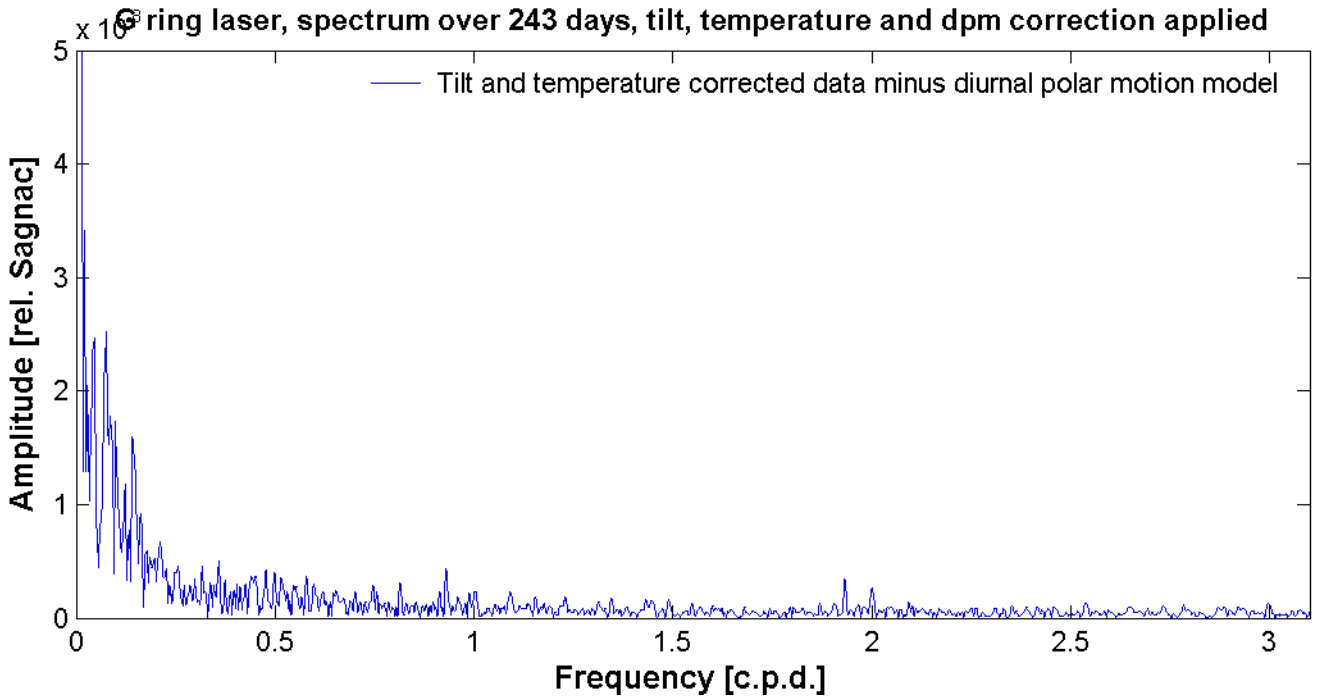
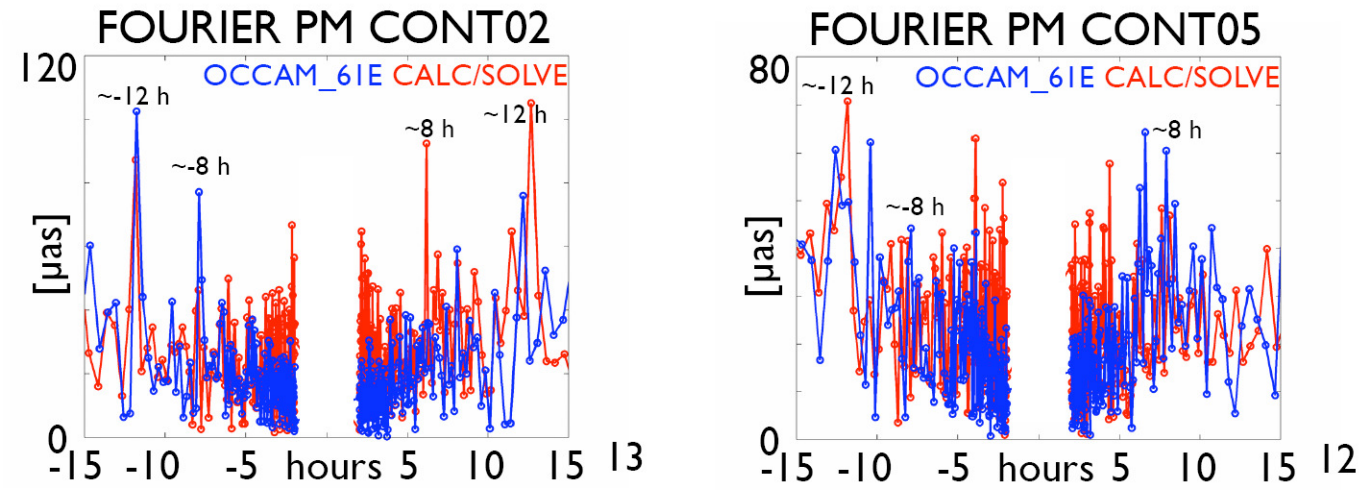
Spectrum of new Time Series

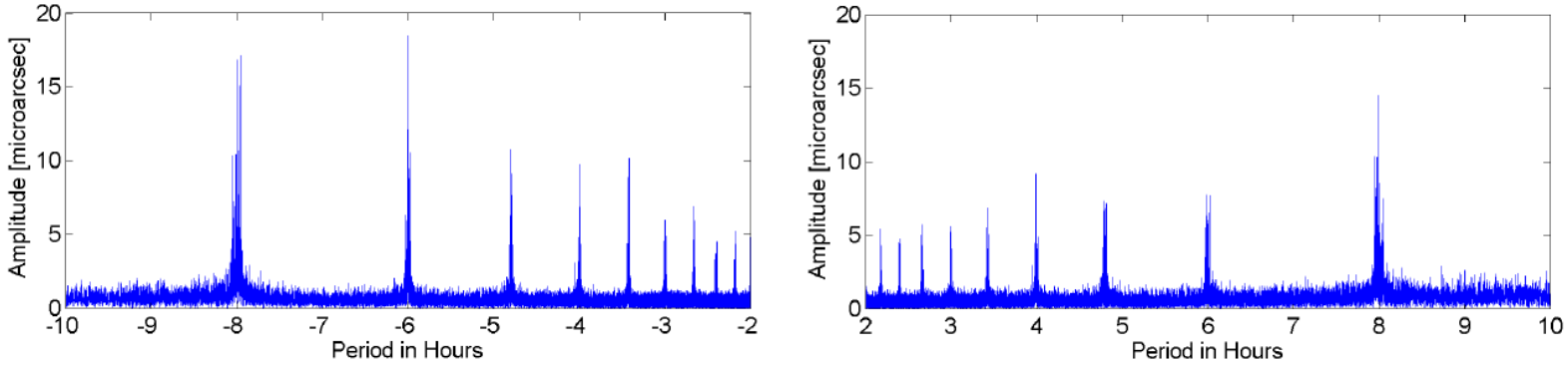


Average noise level at:	1 cpd	2 cpd	3 cpd	4 cpd	
	0.99 e-9	0.67 e-9	0.43 e-9	0.37 e-9	relative Sagnac
	0.236	0.160	0.104	0.088	polar motion [mas]

Signal at 8 Hours?



From: H. Schuh: The intricacies of high-frequency polar motion and universal time variations: status report of the SPEED project. - Status seminar of the research unit “Earth Rotation and Global Dynamic Processes”, Dresden, May 2007



From: P. Steigenberger: GPS-derived long time series of sub-daily Earth rotation parameters. - Status seminar of the research unit “Earth Rotation and Global Dynamic Processes”, Dresden, May 2007

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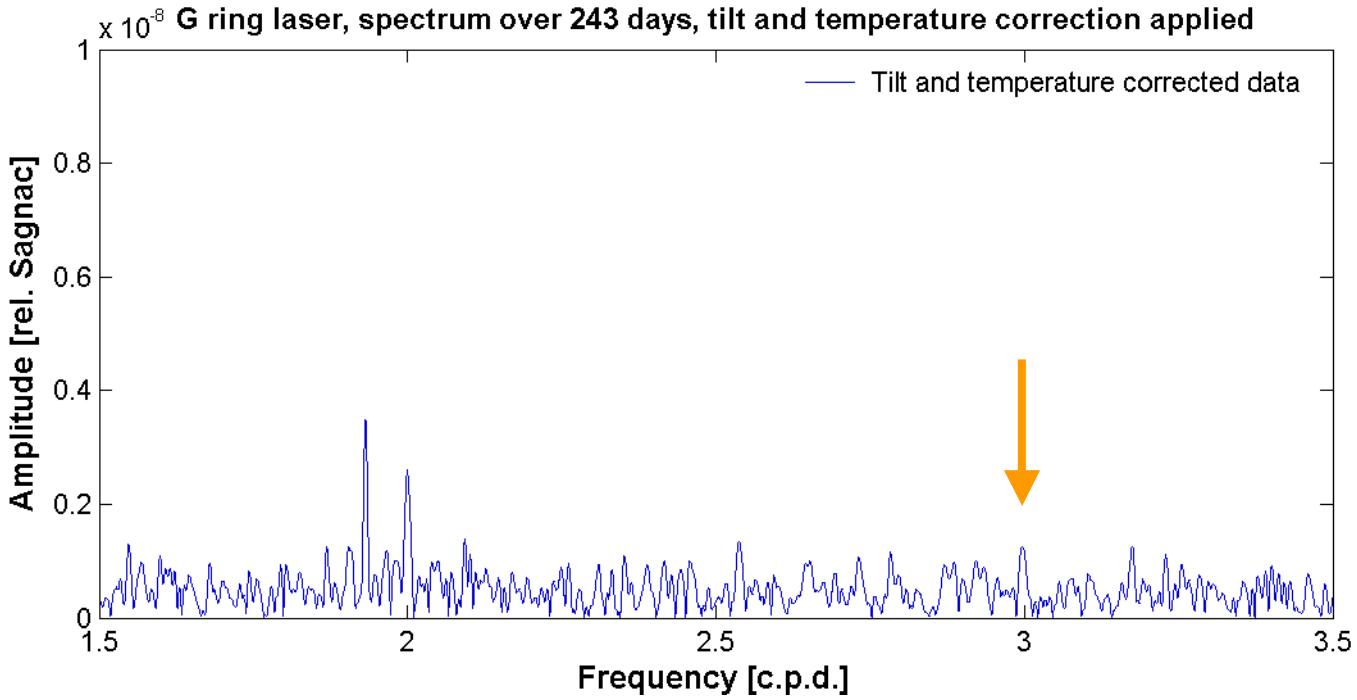
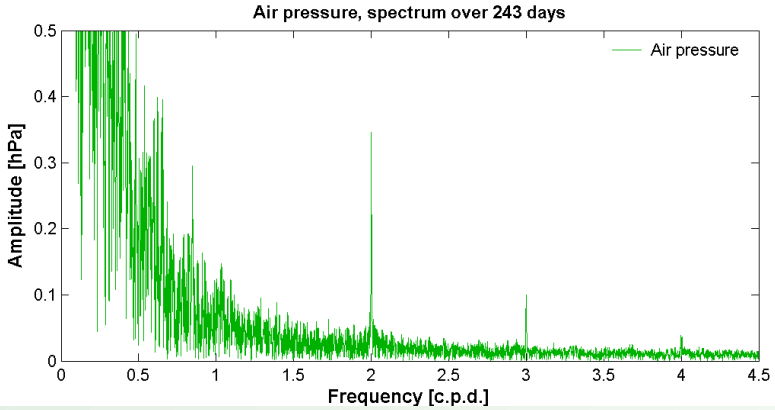
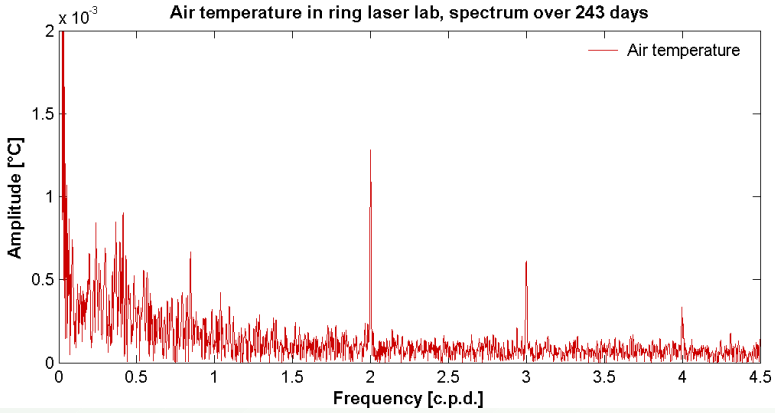
Signal at 8 Hours?







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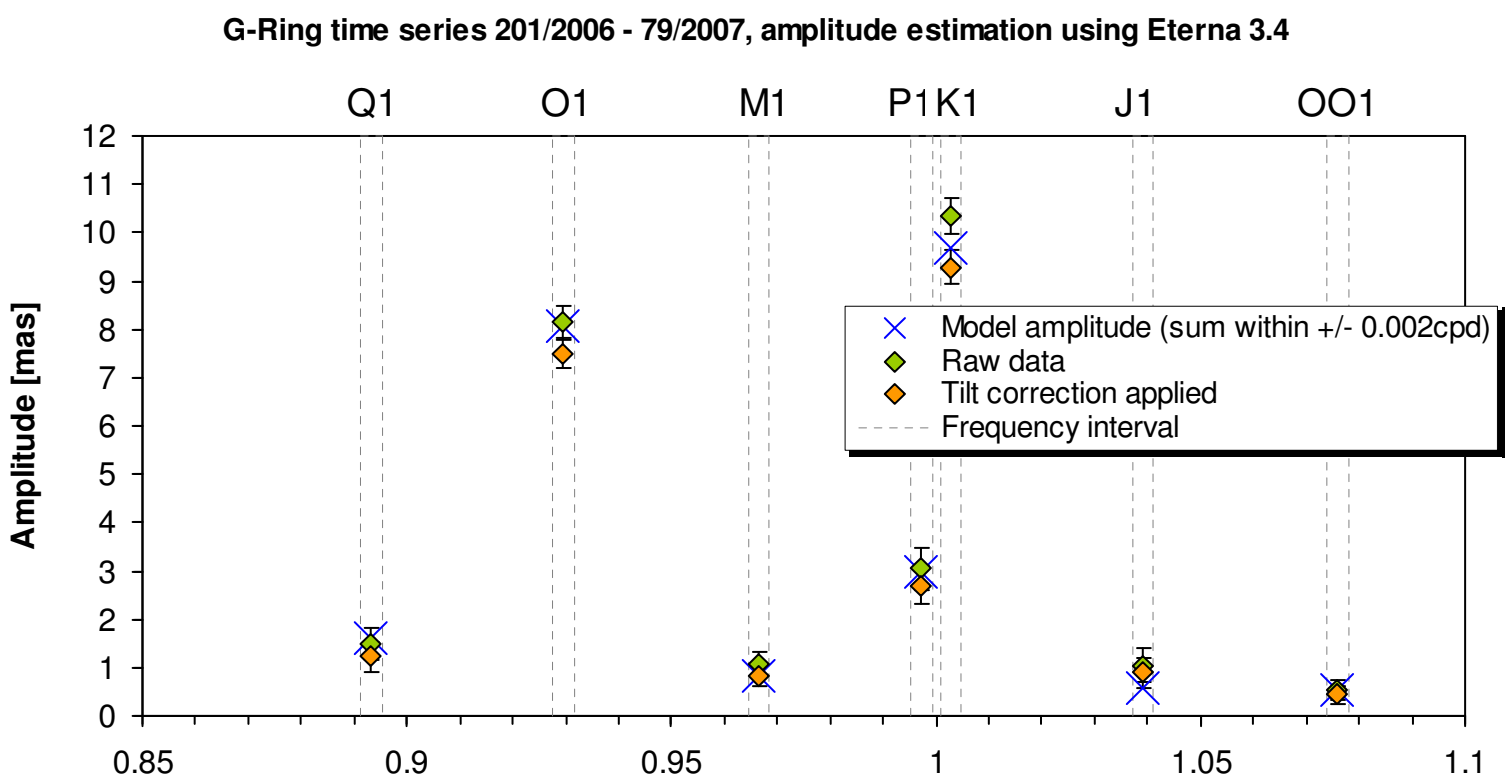
Estimation of Diurnal Polar Motion Terms



Astr. arguments l	l'	F	D	Ω	θ	Symbol	Frequency [c.p.d.]	Matlab raw data Ampl. [mas]	Matlab tilt corr. Ampl. [mas]	Bernese, tilt corrected Ampl. [mas]	*rms [mas]*	Eterna, tilt corrected Ampl. [mas]	*stdev [mas]*	Model [mas]
1	0	2	0	2	-1	Q1	0.8932	1.82	1.61	1.53	*0.07*	1.24	*0.16*	1.59
0	0	2	0	2	-1	O1	0.9295	9.78	8.83	8.65	*0.07*	7.51	*0.16*	8.08
1	0	0	0	0	-1	M1	0.9664	1.32	1.24	1.19	*0.07*	0.84	*0.12*	0.83
0	0	2	-2	2	-1	P1	0.9973	3.18	2.87	2.94	*0.07*	2.70	*0.19*	2.96
0	0	0	0	0	-1	K1	1.0027	10.60	9.66	10.06	*0.07*	9.28	*0.17*	9.69
-1	0	0	0	0	-1	J1	1.0390	0.78	0.63	0.66	*0.07*	0.89	*0.16*	0.57
0	0	-2	0	-2	-1	OO1	1.0759	0.89	0.78	0.67	*0.07*	0.45	*0.09*	0.52
synthetic signal						(1 mas)	1.5000	1.03	1.01					

Summary

- The performance of the Wettzell ring laser has been significantly improved in 2006
- The average noise level at subdaily frequencies is less than 10^{-9}
- Recent detection limit (subdaily signals):
  - Polar motion: 0.4 mas
  - Length of day: 0.15 ms
- The amplitudes of 7 diurnal polar motion terms (Q1, O1, M1, P1, K1, J1, OO1) has been reliably determined with formal errors less than 0.1 mas (Bernese) or 0.2 mas (Eterna)
- Potential for further improvements:
  - new mirrors
  - stabilization of the optical frequency