

Satellites' spin parameters determination from kHz SLR data

Kirchner G., Kucharski D., Cristea E.,
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Grasse 2007

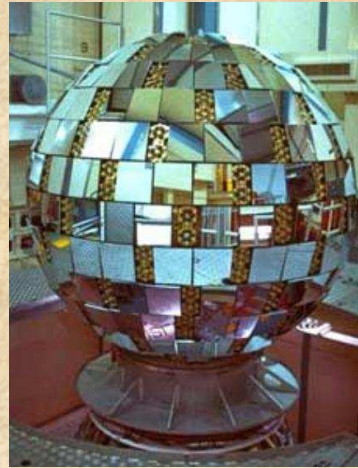
Spin determination from kHz SLR

Already done:

AJISAI

1490 km

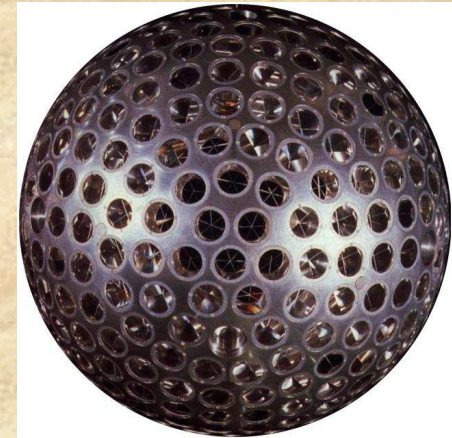
2 s



LAGEOS-1

5860 km

6000 s



Gravity Probe B

650 km

77.5 s

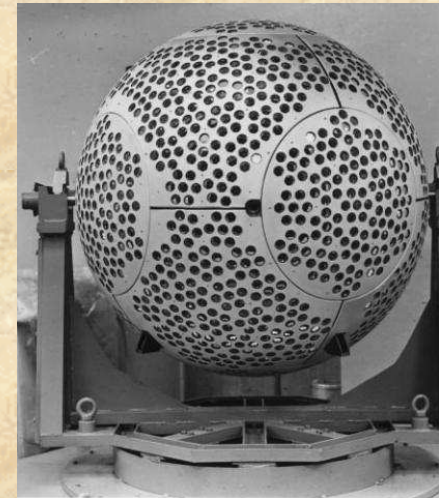


ETALON-1

ETALON-2

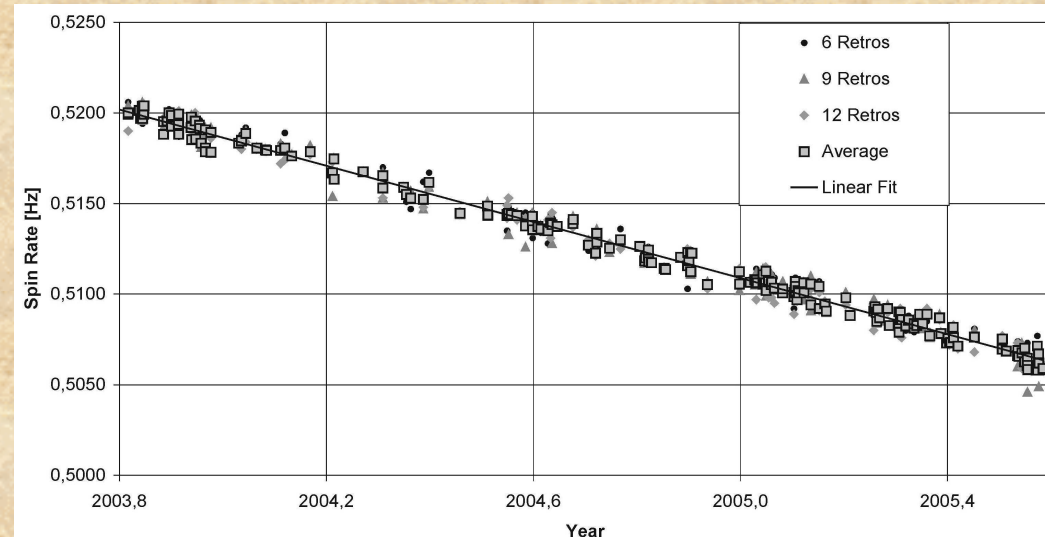
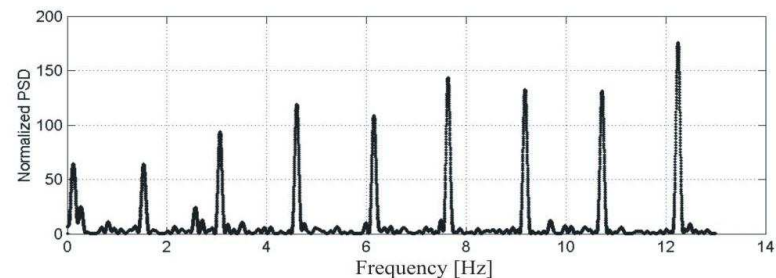
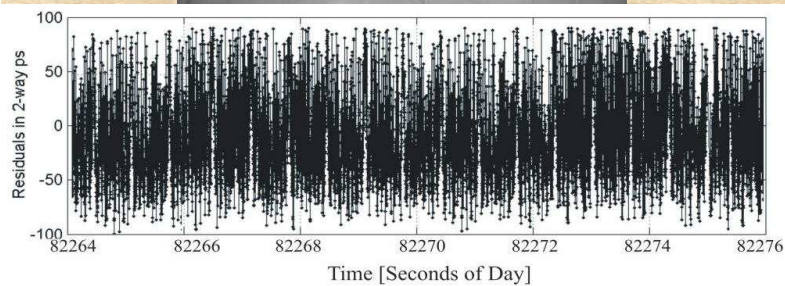
19120 km

65 s



Spin determination from kHz SLR

AJISAI

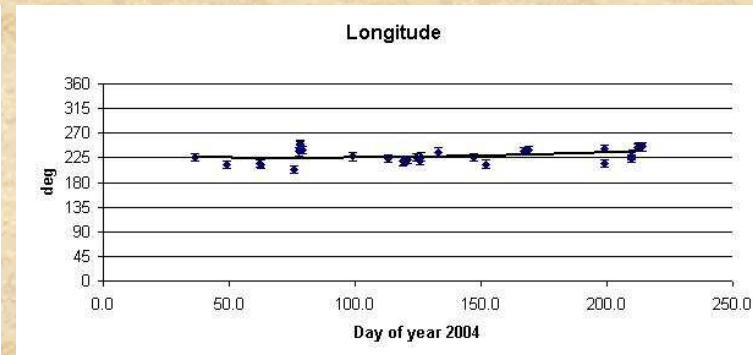
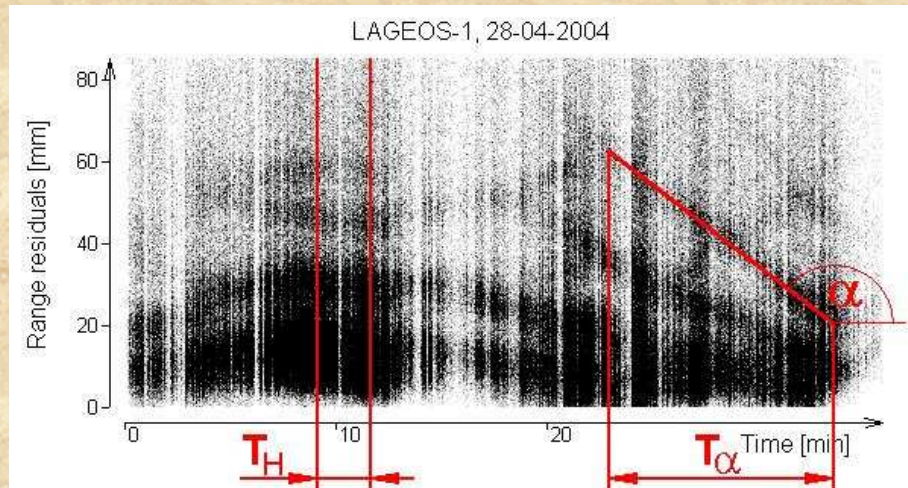
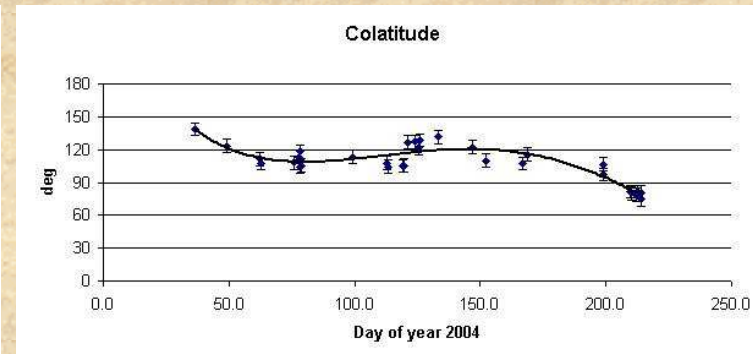
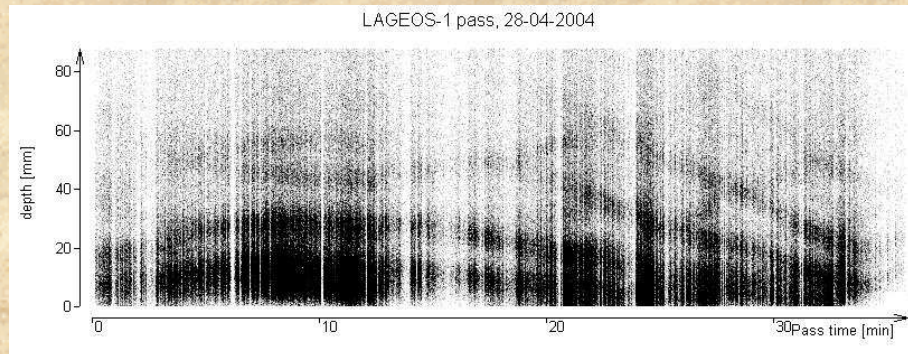


AJISAI spin rate decrease determined from the averages of 6, 9 and 12 retro ring spin rates for 195 passes between 2003/10 and 2005/06. The linear fit to these average values yields a slow down rate of $7.7497 \cdot 10^{-3}$ Hz / year, with a standard deviation of $4.03 \cdot 10^{-4}$ Hz.

Kirchner, G., Hausleitner, W., Cristea, E., "Ajisai Spin Parameter Determination Using Graz Kilohertz Satellite Laser Ranging Data", IEEE Trans. Geosci. Remote Sens., vol. 45, no. 1, pp. 201-205, Jan. 2007

Spin determination from kHz SLR

LAGEOS-1

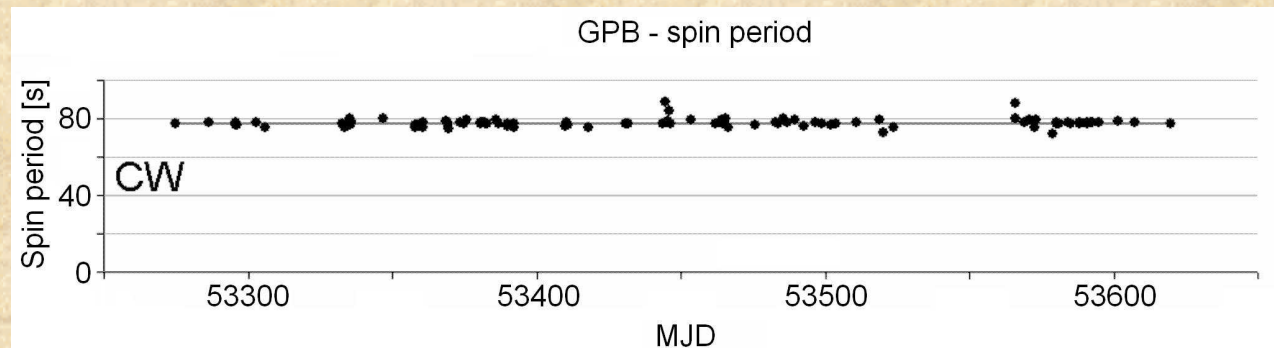
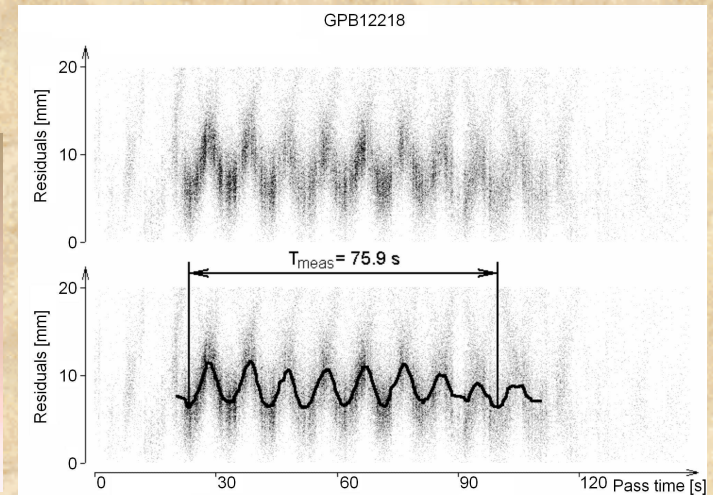
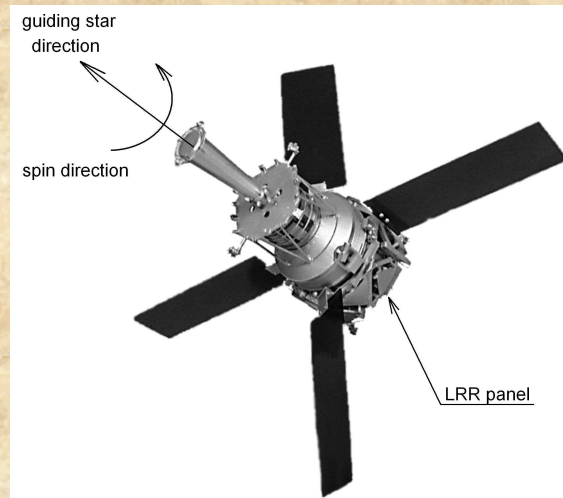


$$T=5775 \text{ s}$$

Kucharski, D., Kirchner, G., Schillak, S., et al. Spin determination of LAGEOS-1 from kHz laser observations. *J. Adv. Space Res.*, 39(10), 1576-1581, doi:10.1016/j.asr.2007.02.045, 2007

Spin determination from kHz SLR

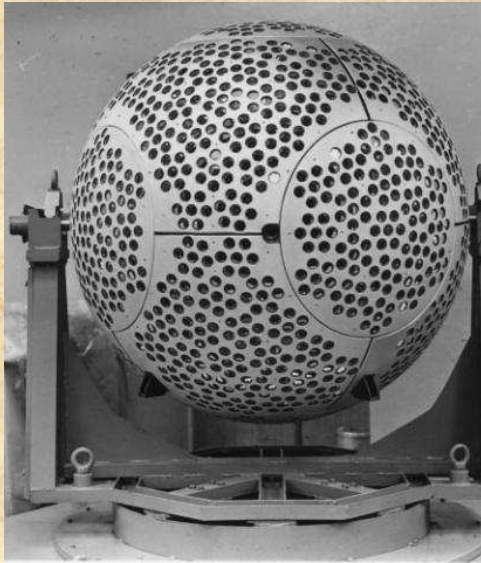
Gravity Probe B



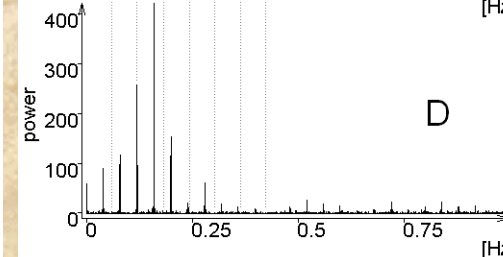
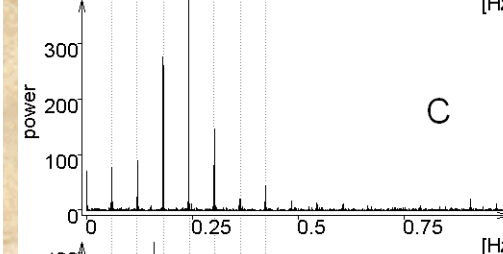
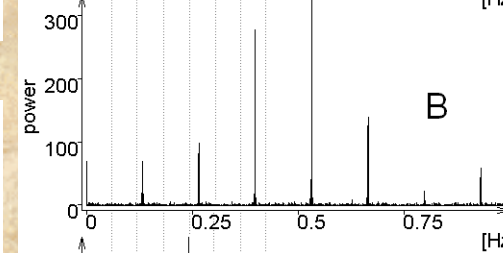
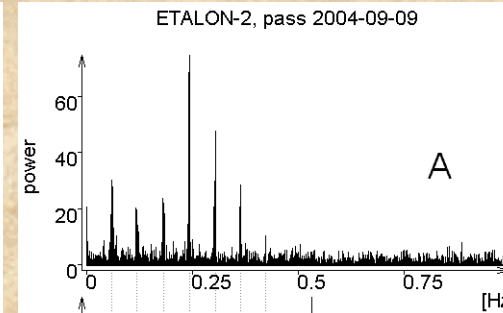
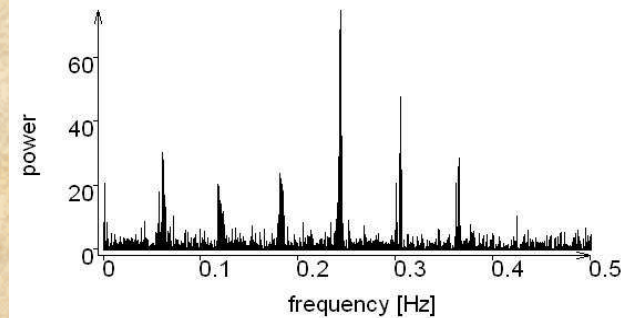
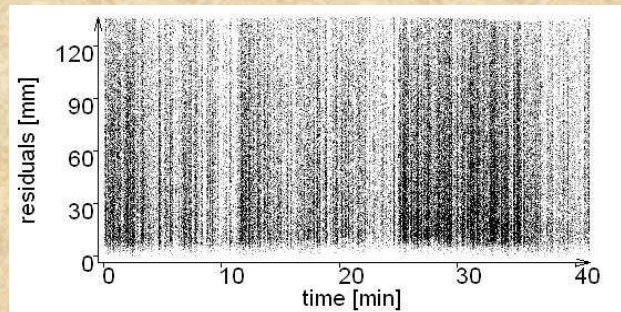
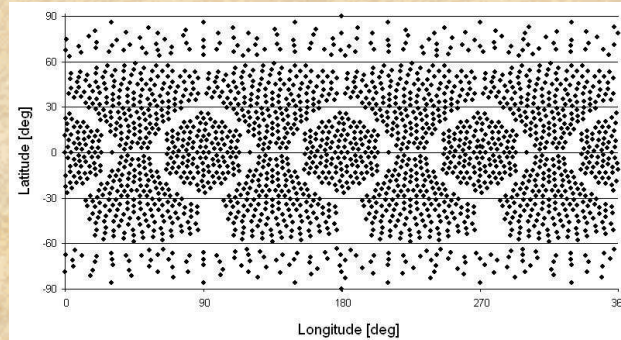
$$\text{RMS}_{\text{LASER-OnBoard}} = 0.98 \text{ s}$$

Spin determination from kHz SLR

ETALON-1, ETALON-2



~70k returns/h



Real
obs.

Sim:
30 s

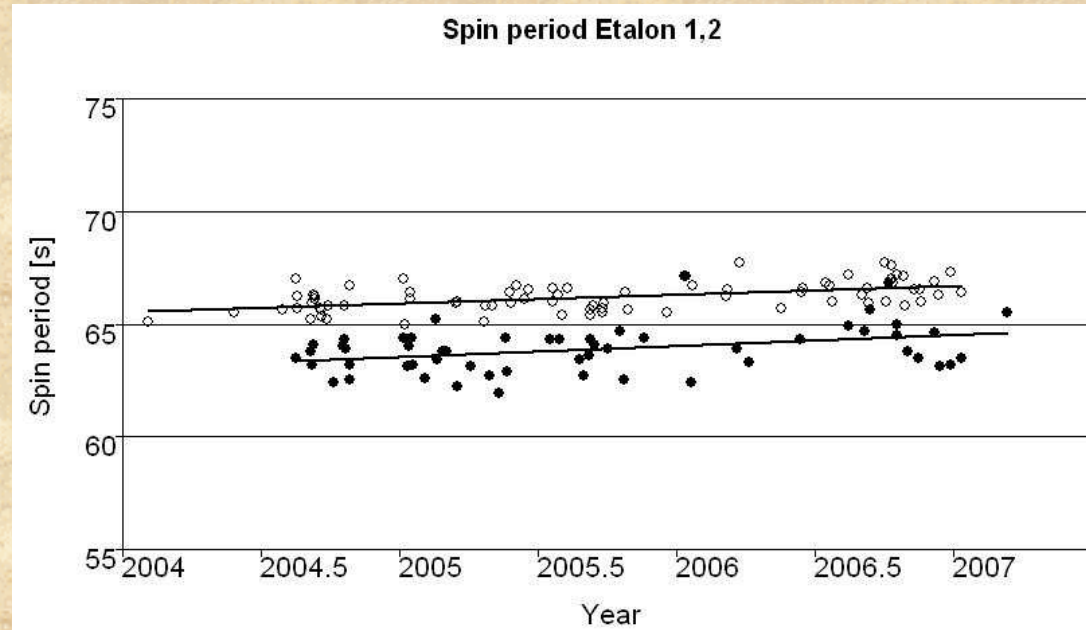
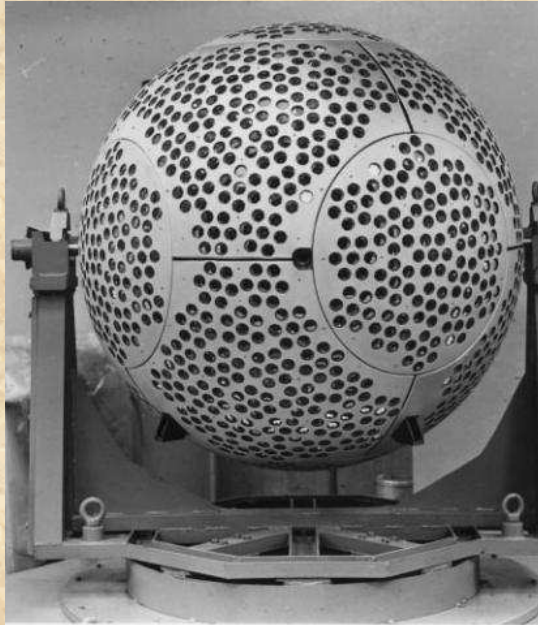
66 s

100 s

6

Spin determination from kHz SLR

ETALON-1, ETALON-2



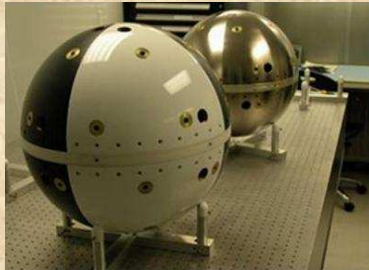
Spin period of the ETALONs is increasing by a value of about 0.5 s/year

RMS ~1%

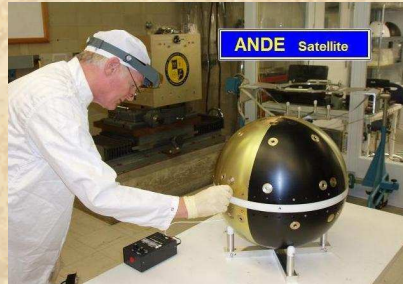
Kucharski, D., Kirchner, G., Cristea, E., ETALON spin period determination from kHz SLR data, J. Adv. Space Res. (2007), doi:10.1016/j.asr.2007.08.030

Spin determination from kHz SLR

Present investigation: ANDE-A



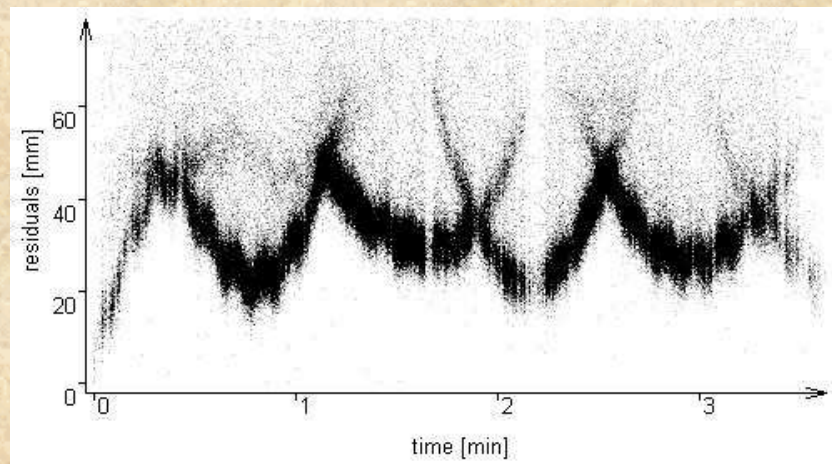
FCal (Front) and MAA (back) [USNA]



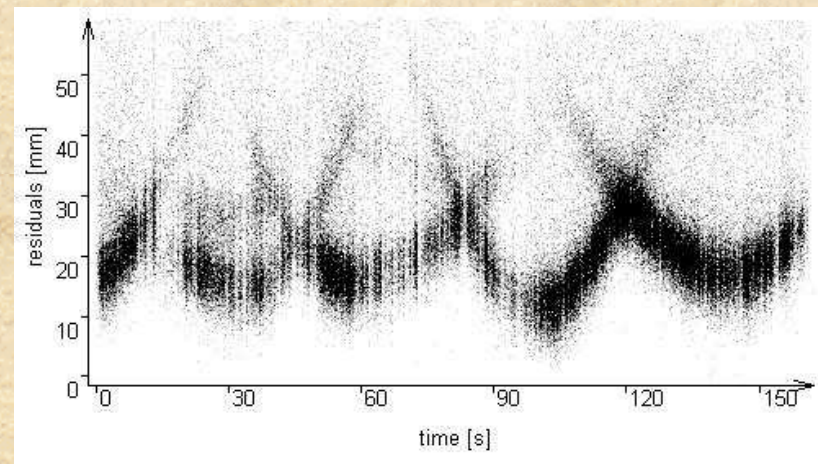
Altitude ~400 km

30 CCRs

14-04-2007, 7 pm



14-04-2007, 10 pm



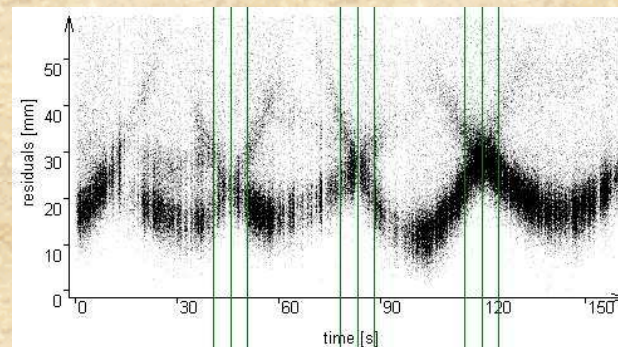
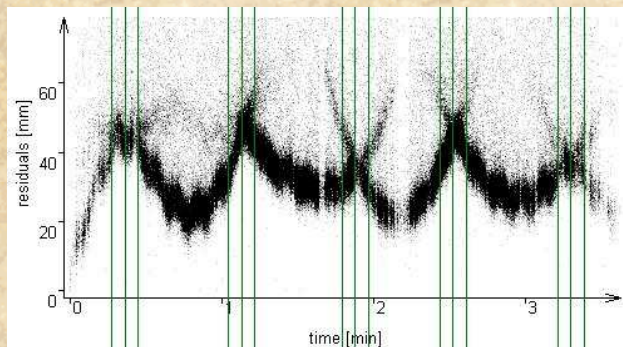
Spin determination from kHz SLR

Present investigation: ANDE-A

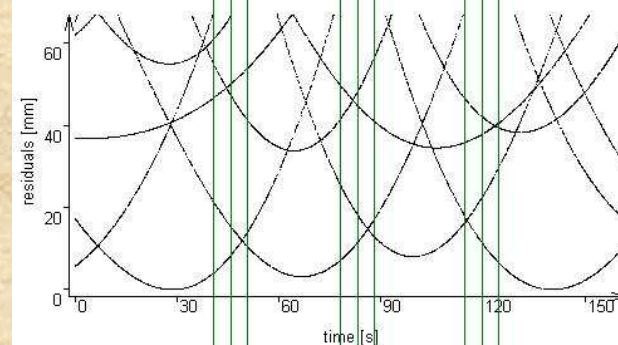
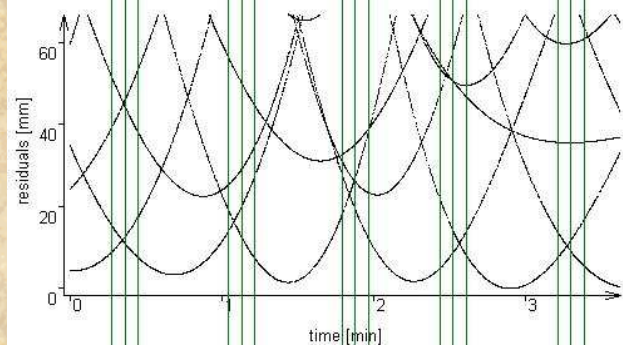
14-April-2007, 7 pm

14-April-2007, 10 pm

OBS



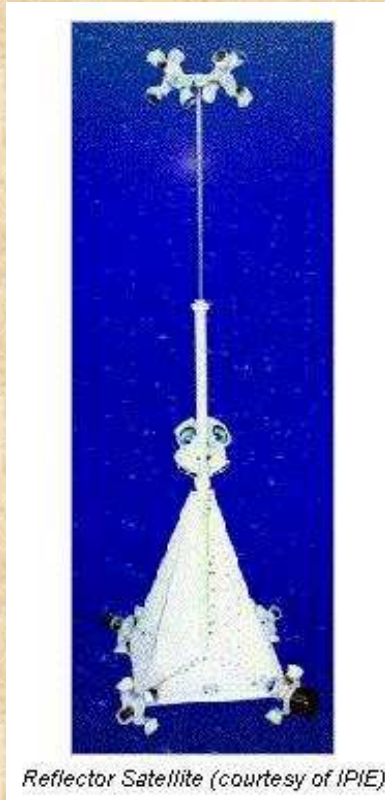
SIM



$T = -670$ s, co-latitude = 65° , longitude = 300°
(J2000 inertial reference frame)

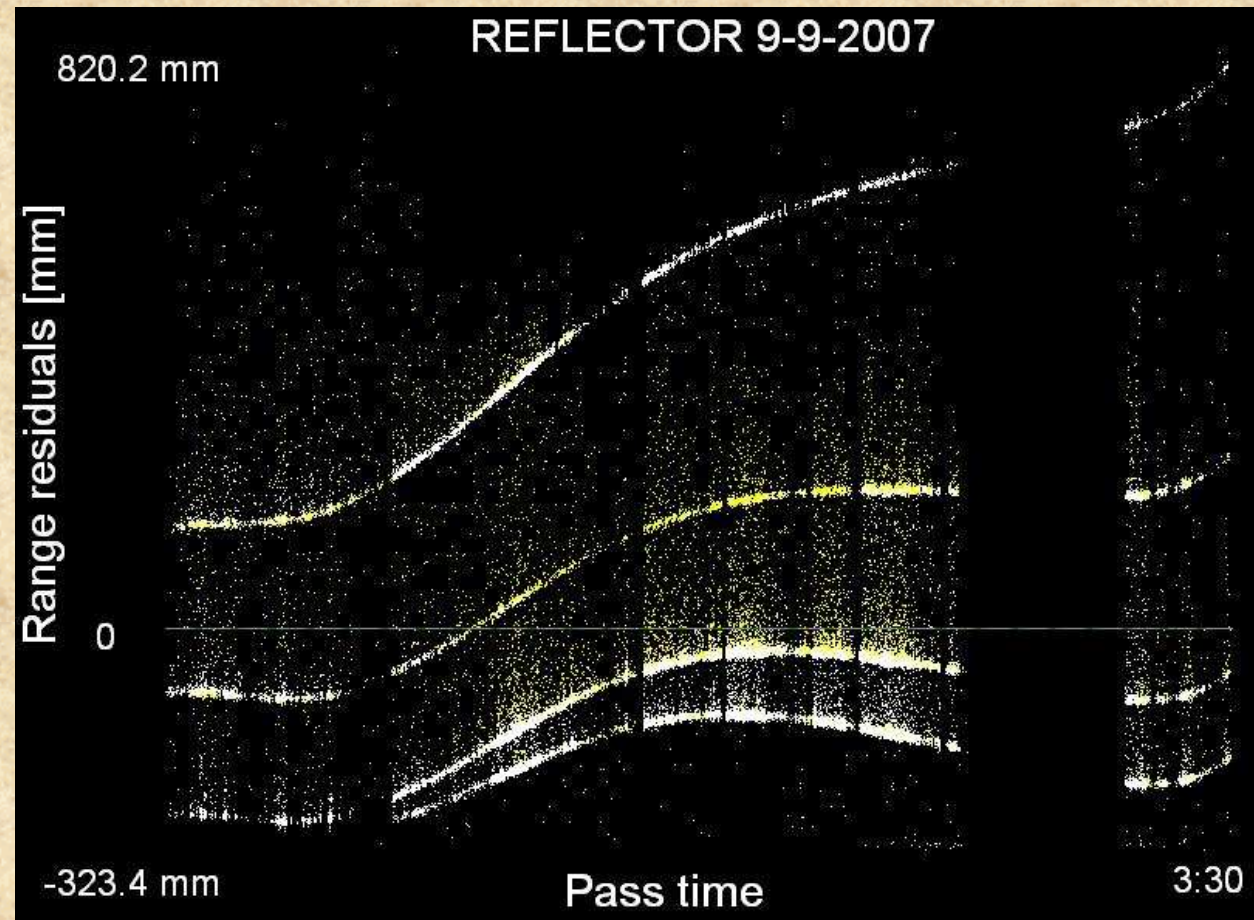
Spin determination from kHz SLR

Future investigation: REFLECTOR



Perigee 1020 km

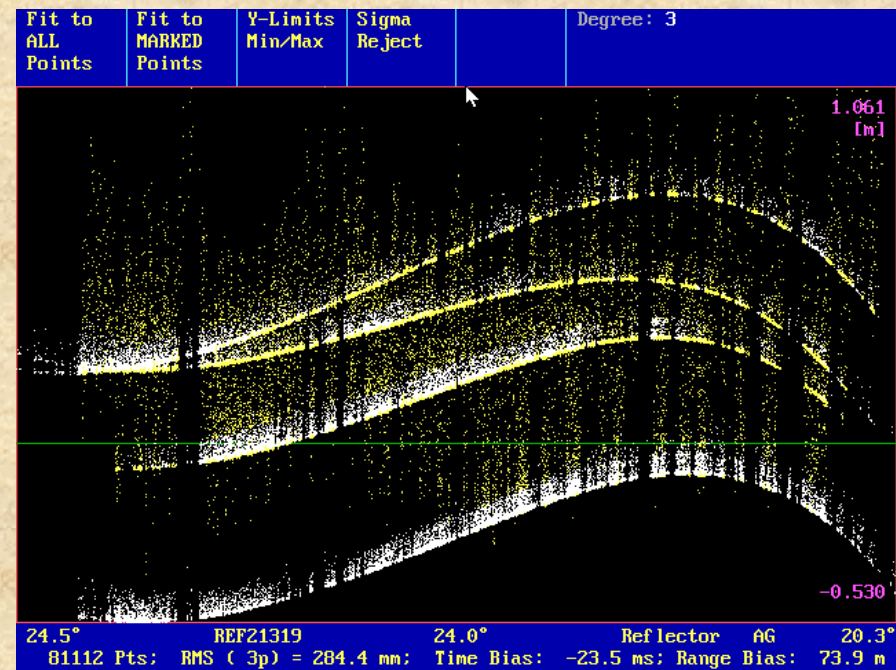
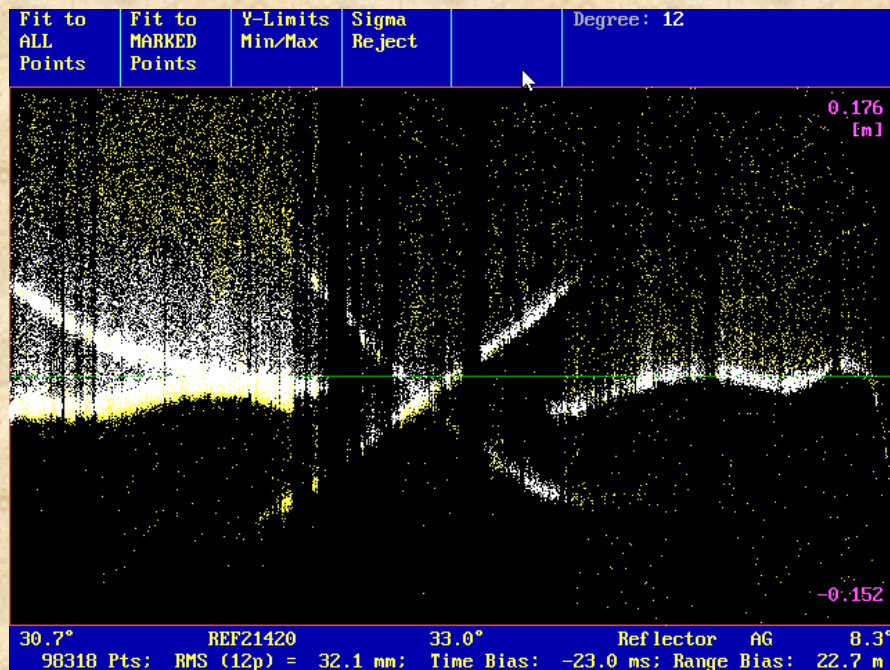
32 CCRs



Spin determination from kHz SLR

Future investigation: REFLECTOR

- more kHz SLR passes (2004)



Spin parameters - application

Improving the accuracy of the perturbations' models

The magnetic torque

$$\Gamma_{\text{magnetic}} = V\alpha'\bar{\omega} \times B(\bar{\omega} \cdot B) - V\alpha''(B \times \bar{\omega}) \times B$$

Bertotti and Iess, 1991

The gravitational torque

$$\Gamma_{\text{gravitational}} = -\frac{3m^2}{4L^2}(C - A)(3\cos^2\vartheta - 1)(n \cdot L)(n \times L)$$

Farinella et al., 1996

Solar radiation pressure causes a torque:

$$\Gamma_{\text{offset}} = \frac{I_0 h C_R A_{\text{cross}}}{c} (s \times r_{\text{sun}})$$

Vokrouhlicky, 1996

Bertotti, B., and Iess, L. The rotation of LAGEOS, J. Geophys. Res., 96 (B1), 2431-2440, 1991

Farinella, P., Vokrouhlicky, D., Barlier F. The rotation of LAGEOS and its long-term semimajor axis decay, J. Geophys. Res., 101 (B8), 17,861-17,892, 1996

Vokrouhlicky, D. Non-gravitational effects on LAGEOS' rotation. Geophys. Res. Lett., 23, 3079-3082, 1996¹²

Spin determination from kHz SLR

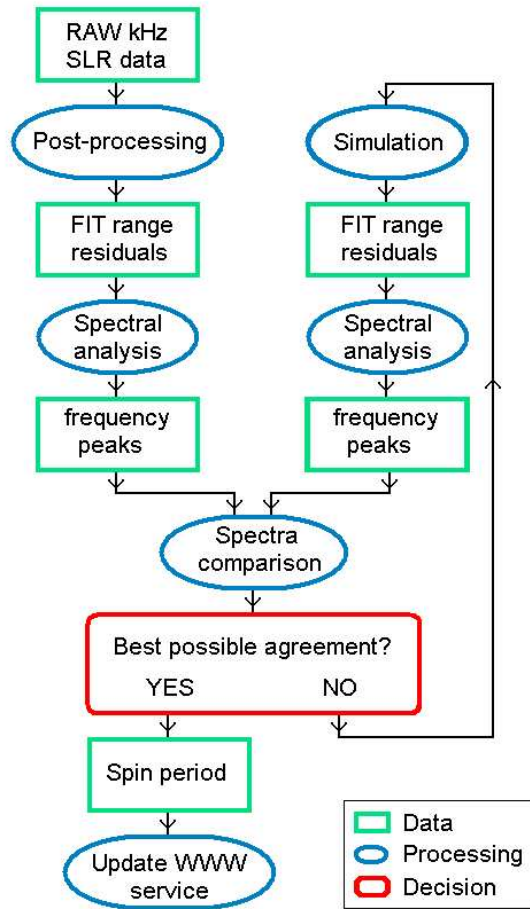
present WEB project:

AJISAI spin period determination from kHz data

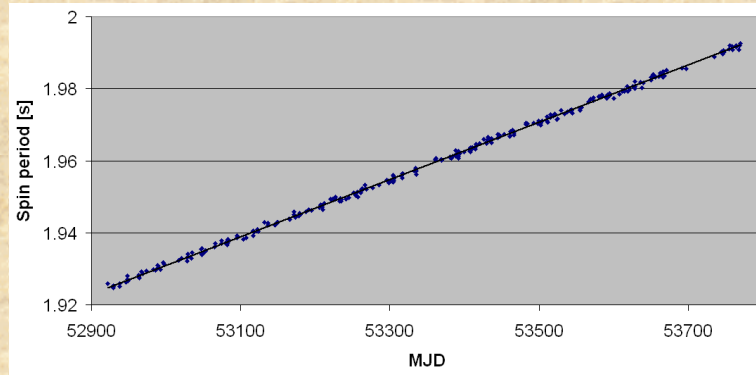
almost real time, 100% fully automatic software



Spin determination from kHz SLR

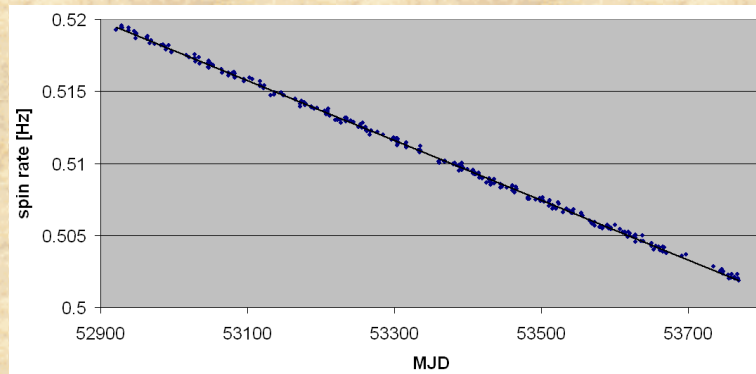


AJISAI spin period data available for the users



start: Sep-2003

next 900 days:
310 passes



RMS of spin period residuals (val-trend line)

$$T_{\text{RMS}} = 5.79 \cdot 10^{-4} \text{ s}$$

RMS of spin rate residuals

$$f_{\text{RMS}} = 1.54 \cdot 10^{-4} \text{ Hz}$$

Spin parameters determination conclusion

kHz SLR allows to determine **the spin parameters** of the satellites
(e.g. AJISAI, GP-B, LAGEOS-1, ETALON-1, ETALON-2)

The spin parameters of the passive satellites change with time, because
of **the perturbing forces**

More kHz stations = **better accuracy** of spin determination,
better orbital coverage with spin data

Satellites' spin parameters determination from kHz SLR data

Thank you

Grasse, 2007