Torques on the LARES Satellite

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LARES vs LAGEOS

	LARES	LAGEOS
material	Tungsten	Aluminum/Brass
diameter	36.4 cm	60.0 cm
mass	387 kg	400 kg
Moments	5.1 x 10^7 gm cm^2 difference 1% - 2%	z: 1.314 x 10^8 gm cm^2 x: 1.271 x 10^8 gm cm^2
inclination	71 deg.	I : 109.8 deg. II: 52.6 deg.

LARES vs LAGEOS

	LARES	LAGEOS
orbital radius	7780 km	I: 12272 x 12272 km II: 11994 x 12328 km
Orbital period	~125 minutes	~250 minutes
Spin	4 - 5 rpm at launch	120 rpm at launch

Earth Magnetic Field

- Assume dipole field aligned with rotation

- $B_r = \frac{-2 \mu \cos \theta}{R^3}$

$$B_\theta = \frac{-2 \mu \cos \theta}{R^3}$$

μ = magnetic moment of the Earth:

7.9×10^{25} Gauss-cm^3

Magnetic Torque

- Spindown torque:
- $N = -V\,\alpha''\,(B_t)^2$
- $\alpha'' \sim a^2\,\sigma\,\omega/(10\,c^2)$

α'' = imaginary part of the magnetization

σ = conductivity

c = speed of light

LARES Magnetic Spindown

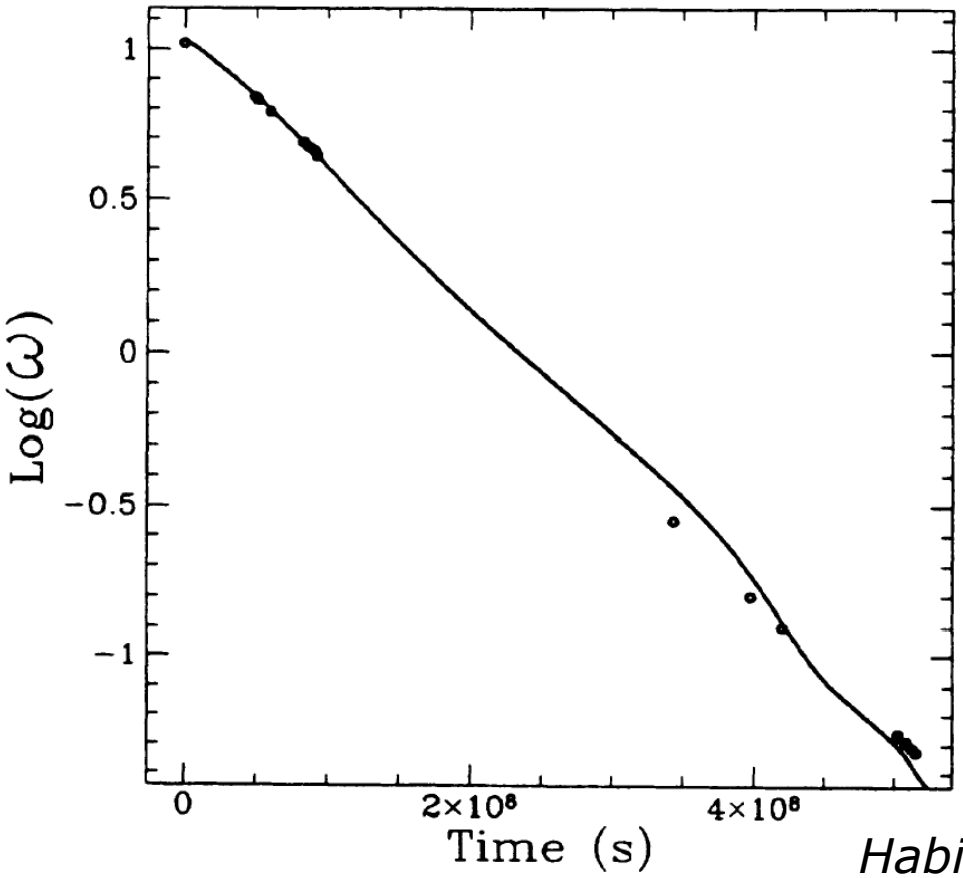
$$\dot{\omega} = -[\frac{4\pi}{30}\frac{a^5\sigma}{I}B_t^2]\omega$$

$$= -[\frac{4\pi}{30}\frac{a^5\sigma}{I}B_t^2]_{LAGEOS}$$

$$\times \frac{B_{t\,LARES}^2}{B_{t\,LAGEOS}^2} \times \frac{a_{LARES}^3}{a_{LAGEOS}^3} \times \frac{\sigma_{LARES}}{\sigma_{LAGEOS}} \times \frac{M_{LAGEOS}}{M_{LARES}}\omega$$

$$\times 15.39 \times 0.223 \times 0.643 \times 1.034 = \times 2.28$$

LAGEOS Spindown



LAGEOS initial spin period ~ 0.5 second

LAGEOS spindown:

One order of magnitude per 2.3 x 10^8 seconds (about seven years)

*Habib et al PRD **50** 6068 (1994)*

LAGEOS SPINDOWN

LAGEOS was launched in 1976 order of magnitude spin decay in ~7 years.

LAGEOS spin decays to orbital rate after about 25 years

Spin behavior became very complex as spin and orbit pass into (through?) resonance

LAGEOS now has no remnant of initial spin axis, very small spin rate.

LARES SPINDOWN

LARES spindown 2.28 faster than LAGEOS-

order of magnitude spin decay in ~3 years.

Orbital Period ~ 125 minutes;
initial spin period 0.2 minutes

Less than three orders of magnitude-
"chaotic" spin behavior within 9 years!

IMPLICATIONS

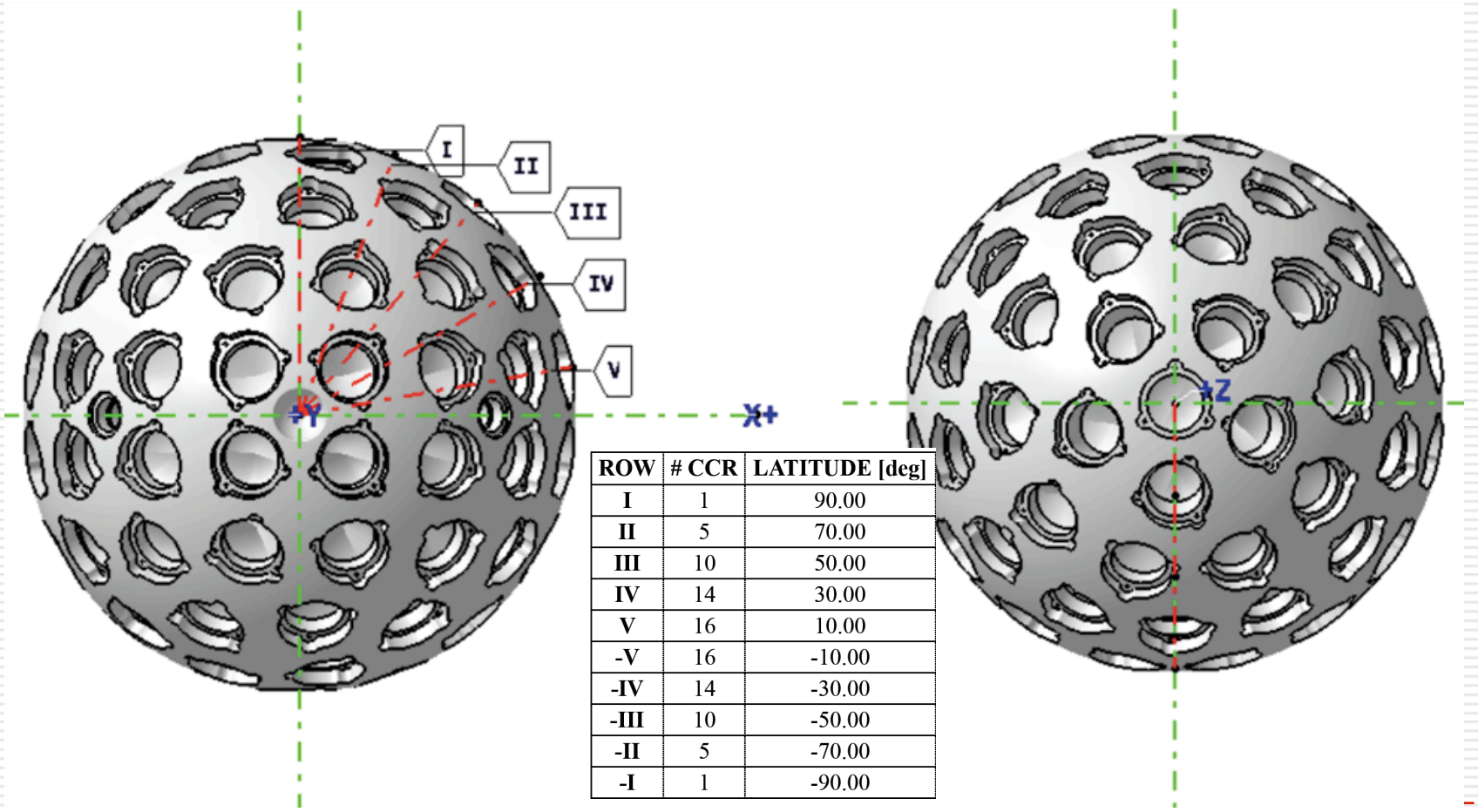
- Nine years is a short time!
  - tides

- Rubuncam / Yarkowski ("thermal rocket") effect

- "Guaranteed" eclipses

-Spin observation of LARES is essential

LARES REFLECTOR LAYOUT



ROW	# CCR	LATITUDE [deg]
I	1	90.00
II	5	70.00
III	10	50.00
IV	14	30.00
V	16	10.00
-V	16	-10.00
-IV	14	-30.00
-III	10	-50.00
-II	5	-70.00
-I	1	-90.00