The Excited Rotation State of 2P/Encke

Michael J.S. Belton

Belton Space Exploration Initiatives, LLC, Tucson, AZ 85716. USA

(belton@azstarnet.com)

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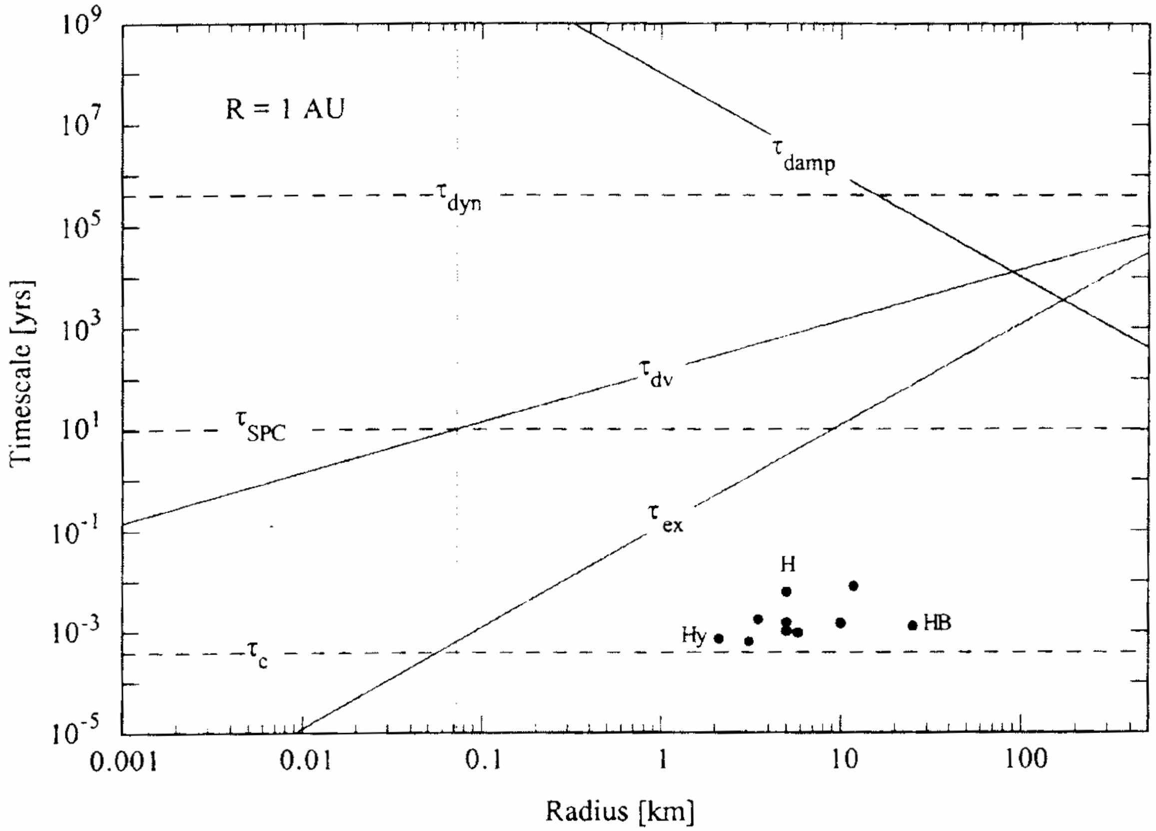
Are comet nuclei in excited spin states common?

- **Discussed by Samarasinha et al (1986, 1995) and Jewitt (1991, 1997)**
- **Jewitt (1997) finds $\tau_{ex} \sim 0.1r^2$ yrs or about 2.5 yrs for a 5 km radius nucleus at 1AU.**
- **Samarasinha (1999) has compared a number of comets with 1P/Halley which is known to be in a excited state: $\tau_{ex} \sim r^4/P^*Q_{H2O}$**

Comet	Effective Radius (km)	Period (d)	Q_{H2O} (Perihelion)	τ_{ex}/τ_{Halley}	Observed spin state
46P/Wirtanen	~0.6	~0.3	$1.3\text{-}2.5.10^{28}$	0.08 - 0.15	?
1P/Halley	5.2	2.8	$1.3.10^{30}$	1	Excited
2P/Encke	3-5	0.63	$4.5.10^{28}$	14 - 110	?
9P/Tempel 1	2.7-3.8	0.5-4.5	2.10^{28}	3 – 104	?
C/Hale-Bopp	~30	0.46	$1.5.10^{31}$	584	Pure
29P/S-W 1	8.6 –15.4	0.58	5.10^{28} (CO)	939-9,655	Excited (?)

- **ROSETTA target, 49P/Wirtanen, is most likely to be in an excited spin state. CONTOUR (2P/Encke) and DEEP IMPACT (9P/Tempel 1) targets are a possibility….**

Timescales for cometary processes (after Jewitt (1997)



τ_{damp} – Damping timescale

τ_{dyn} – Median dynamical lifetime of SPCs

τ_{dv} - Devolatilization timescale

τ_{ex} – Spin excitation time

τ_{SPC} – SPC mean orbital period

τ_c – Max. period with no strength

2P/Encke: Determination of periodicities

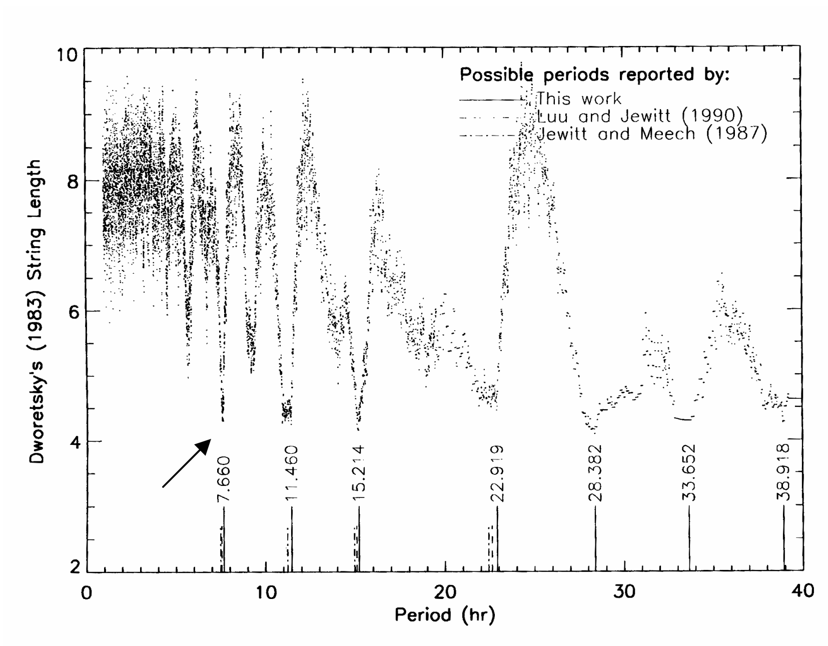
- **String-length (Dworetsky 1983) and phase-dispersion (Stellingwerf 1978) methods are usually used.**
- **WindowCLEAN algorithm makes use of the "sampling window" function to remove aliases. Spurious frequencies are still possible……..**
    - **Roberts et al (1987)**
    - **Foster (1995)**
    - **Belton & Gandhi (1988): Meech et al (1993)**

- **Four independent data sets available:**

Observers	**Telescope**	λ	**Year**	**Dates**	**Data points**	**R(au)**
Jewitt & Meech	KPNO 4m	R	1985	Sept. 22-23	25	4.06
Jewitt & Meech	KPNO 2.1m	R	1986	Oct. 30-31; Nov. 01-03	15 47	3.15
Luu & Jewitt	McGraw-Hill 2.4 m	R	1988	Sept. 3,6,7	101	3.83
Fernandez thesis	ESO 3.6m	10.7μ	1997	July 17-19	~50	1.2

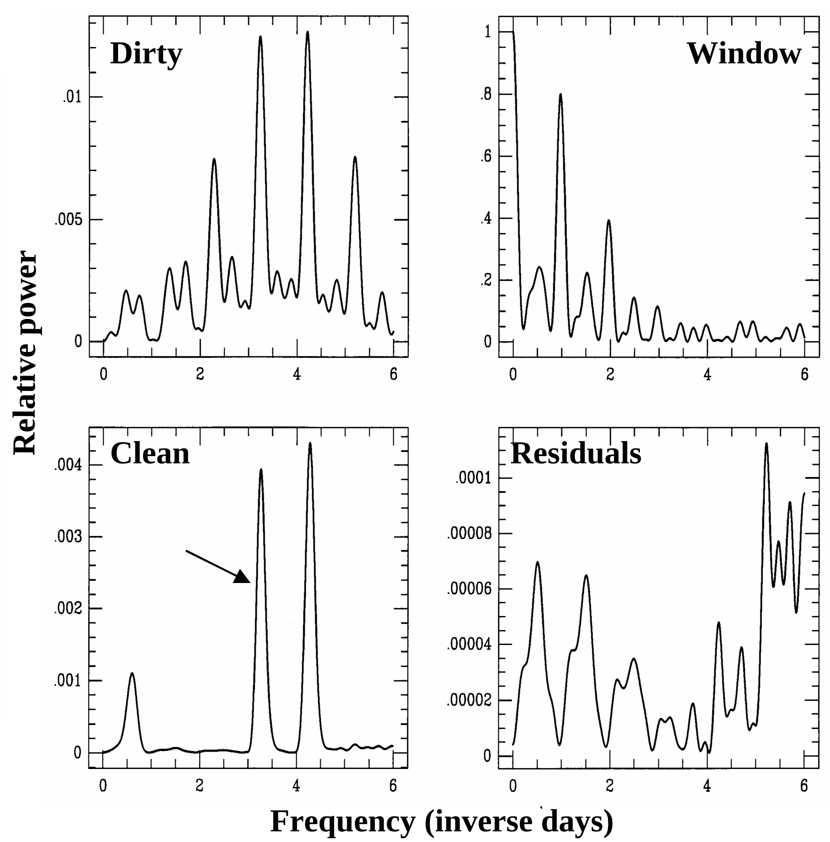
2P/Encke – A Comparison of methods

STRING LENGTH



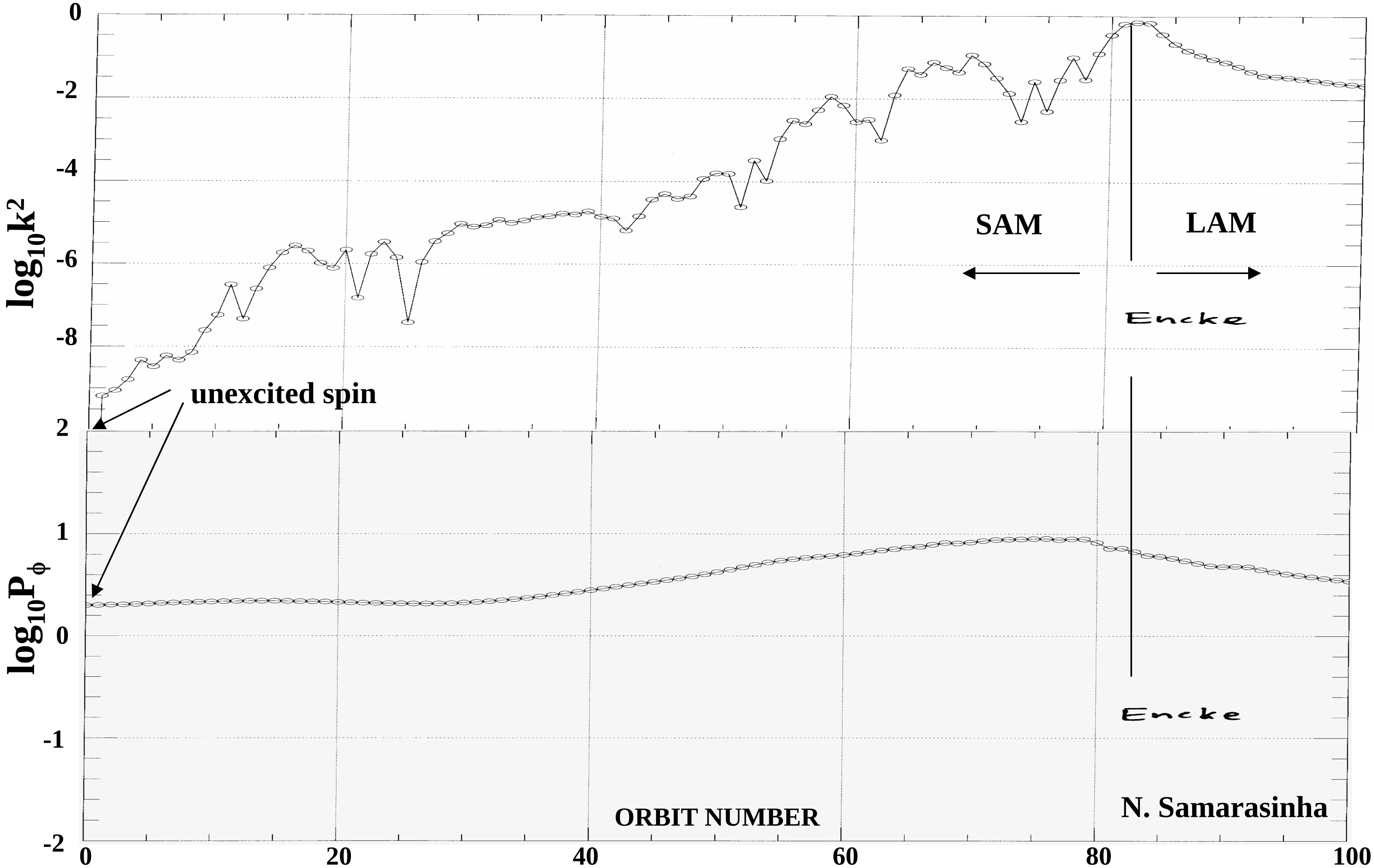
Fernandez thesis (1999) 10.7μ data

WINDOWCLEAN



Excitation in an 2P/Encke orbit.

(Initial period= 2 days; a:b:c = 8:4:3.5; Five active areas; Q = 1.7.10^{28} mol/s; Orbit =2P/Encke)



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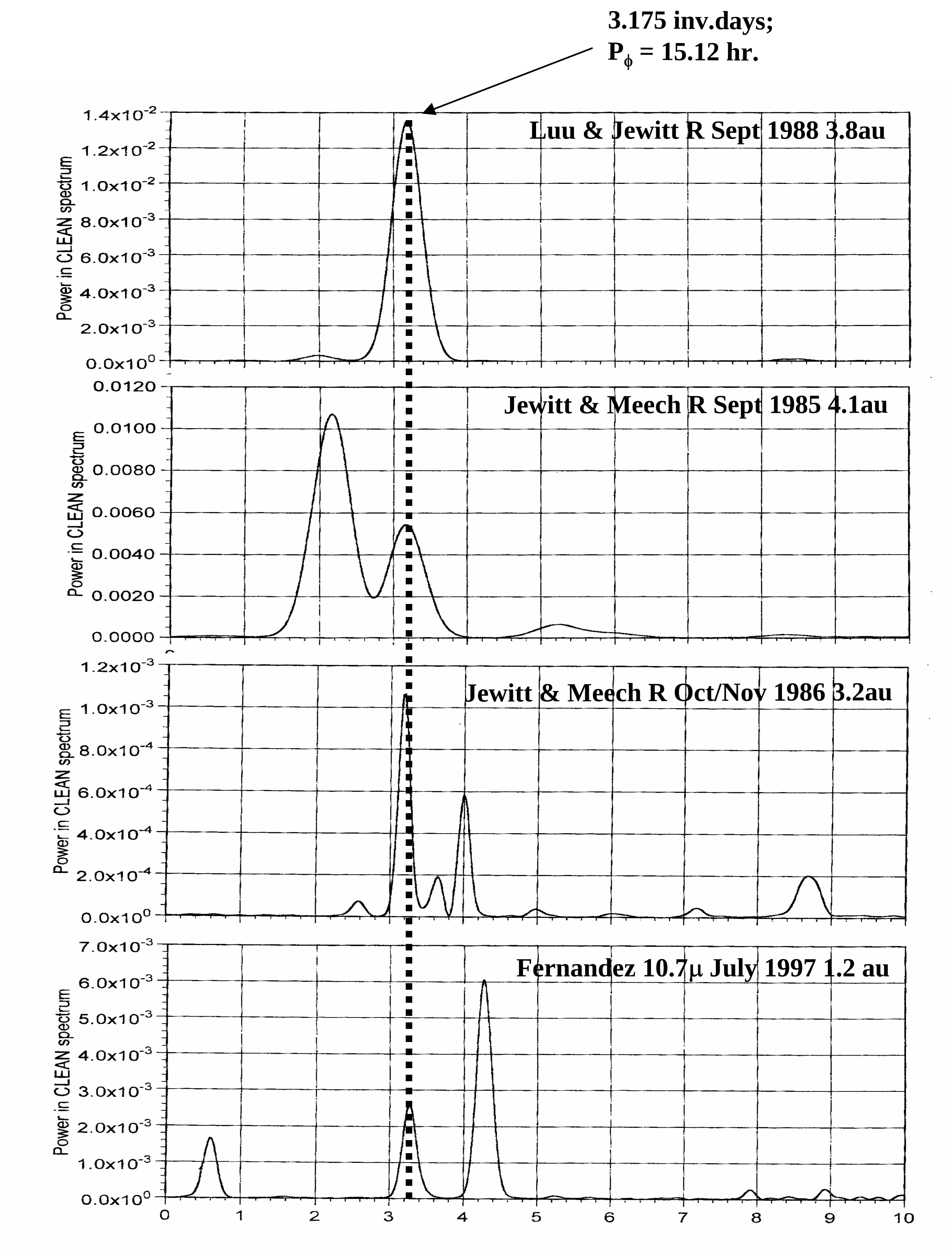
2P/Encke –results:



Frequency (inverse days)

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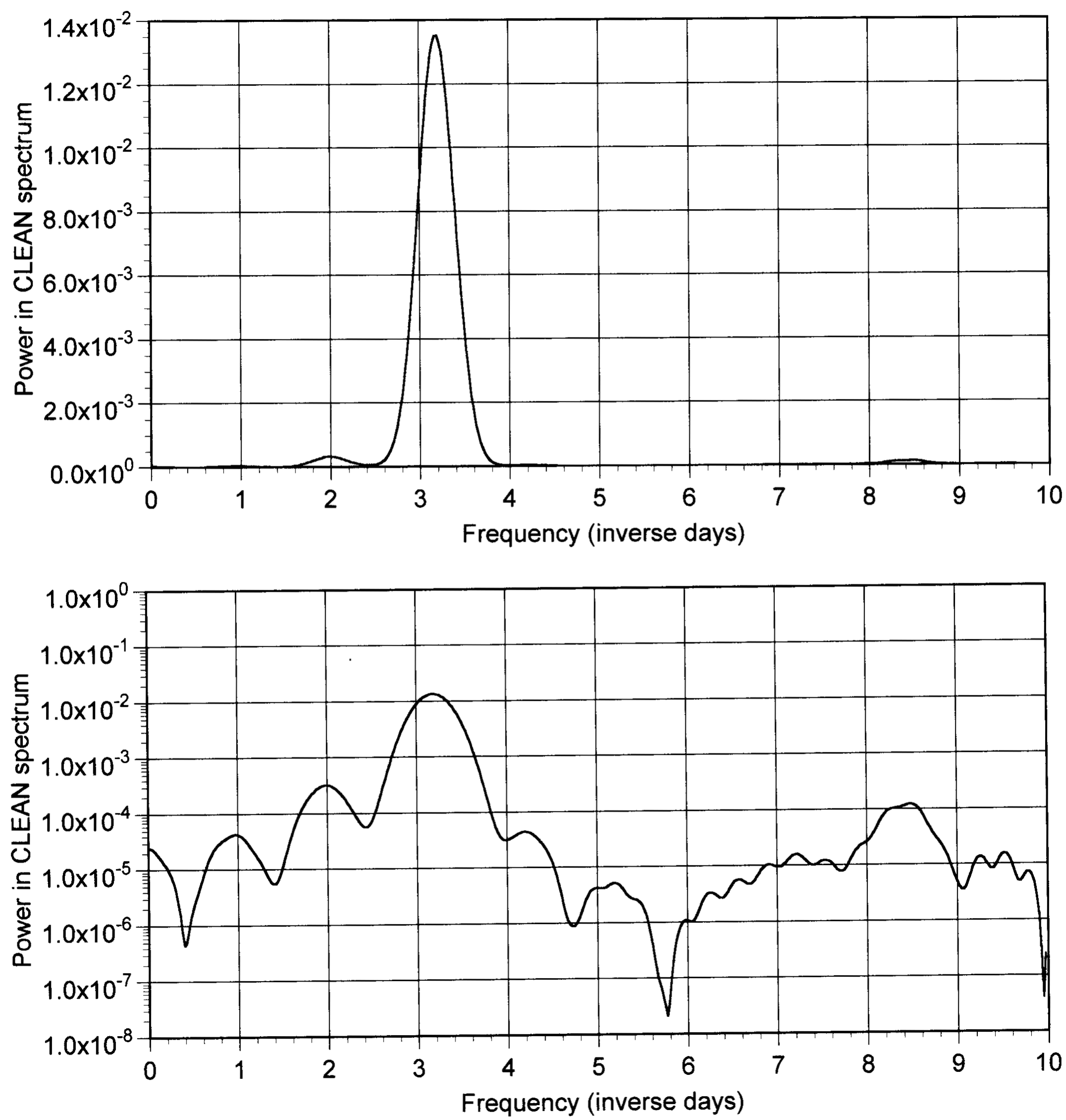
P/Encke: Luu and Jewitt



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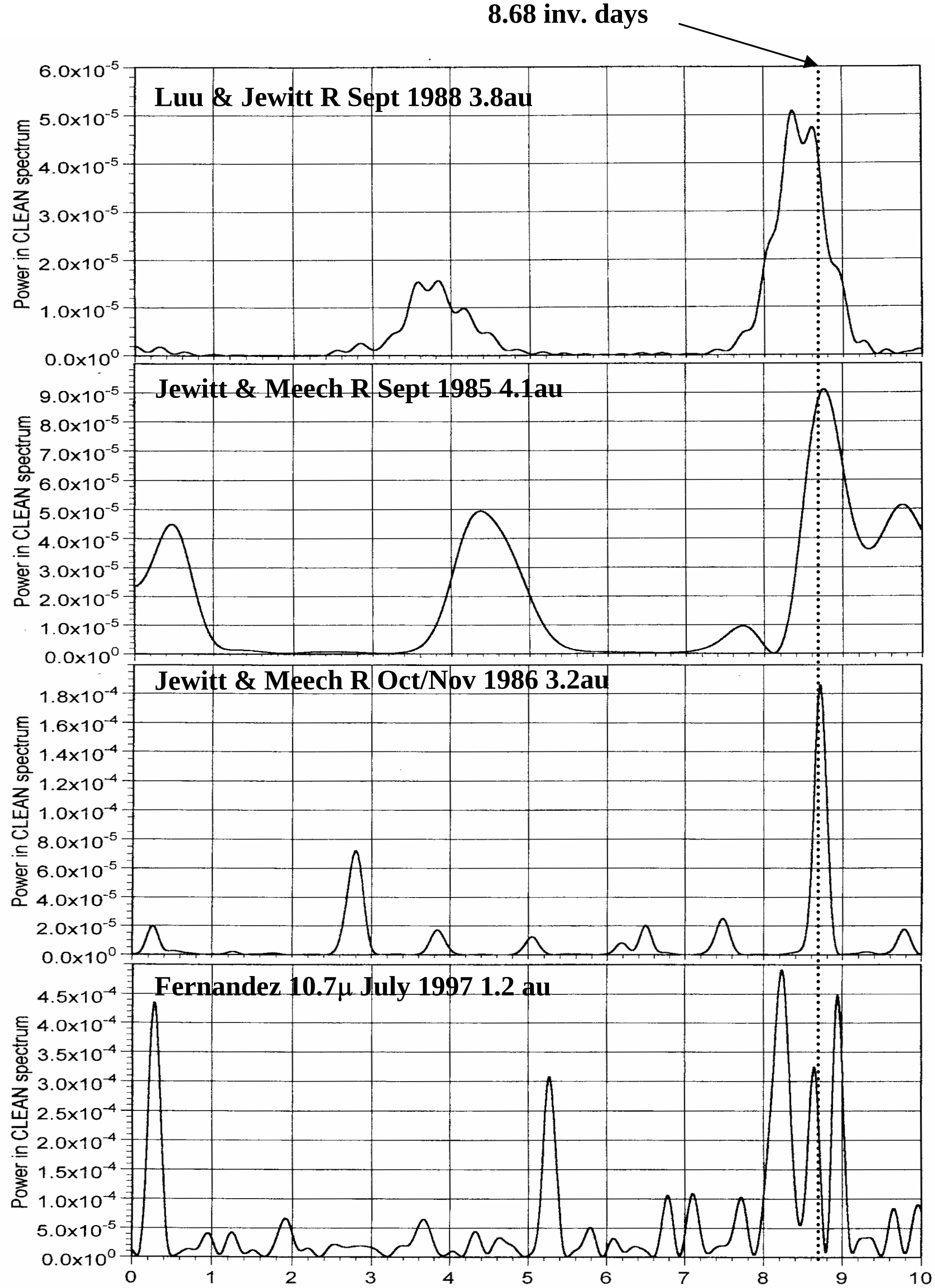
2P/Encke –WindowClean of 3.1 inv.day whitened data



Frequency (inverse days)

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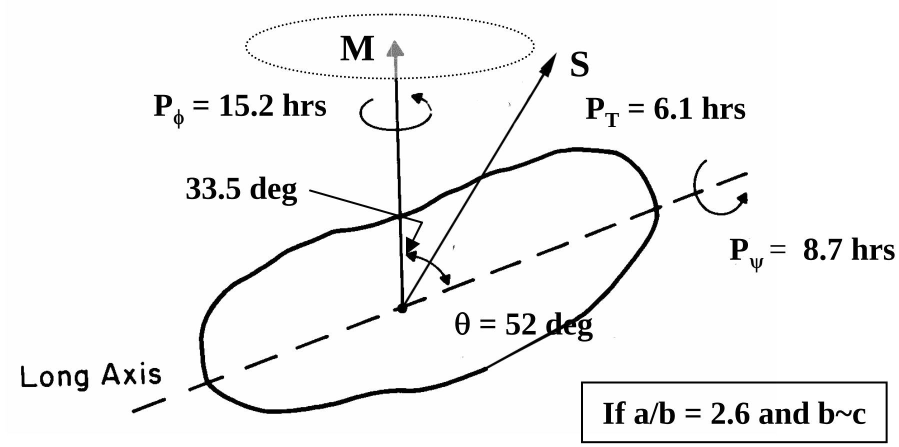
2P/Encke – Second frequency is an unexpected result. Implications if the nucleus is in an excited spin state:

- **Two frequencies: ω_1 = 3.175 inv. Days; ω_2 = 8.68 inv days**
- **Using model simulations to identify periodicities (Kryszczy∏ska et al 1999; Meech et al 1993):**
  - **$\omega_1 = 2/P_\phi$ & $\omega_2 = 2/P_\phi + 2/P_\psi$**
  - **P_ϕ = 15.2 hrs**
  - **P_ψ = 8.7 hrs**



- **SAM or a LAM?**
  - **For SAM's $P_\psi / P_\phi > 1$ (Samarasinha & A'Hearn, 1991)**
  - **Must be a LAM…..**
  - **If a > b ~ c then a/b > 2.1 consistent with lightcurve amplitudes**
  - **If a/b ~ 2.6 (Fernandez thesis using Sekanina pole) then: θ ~ 52 deg**
  - **Total spin period ~6.1hr; spin vector (S) is inclined to angular momentum vector (M) by ~ 33.5 deg and circulates once every 15.2 hrs.**

Conclusions:

1. Two periodicities exist in the observed light curves of 2P/Encke.
2. The nucleus is spinning in an excited state, probably a LAM.
3. If the nucleus shape is elongated with $a > b \sim c$ then:
   - $a/b > 2.1$ from the periodicities alone.
   - 15.2 hrs is the precession of the long-axis around **M**
   - The instantaneous spin period could be several times less.
4. Re-analysis of light curve amplitudes and fan orientations is needed.