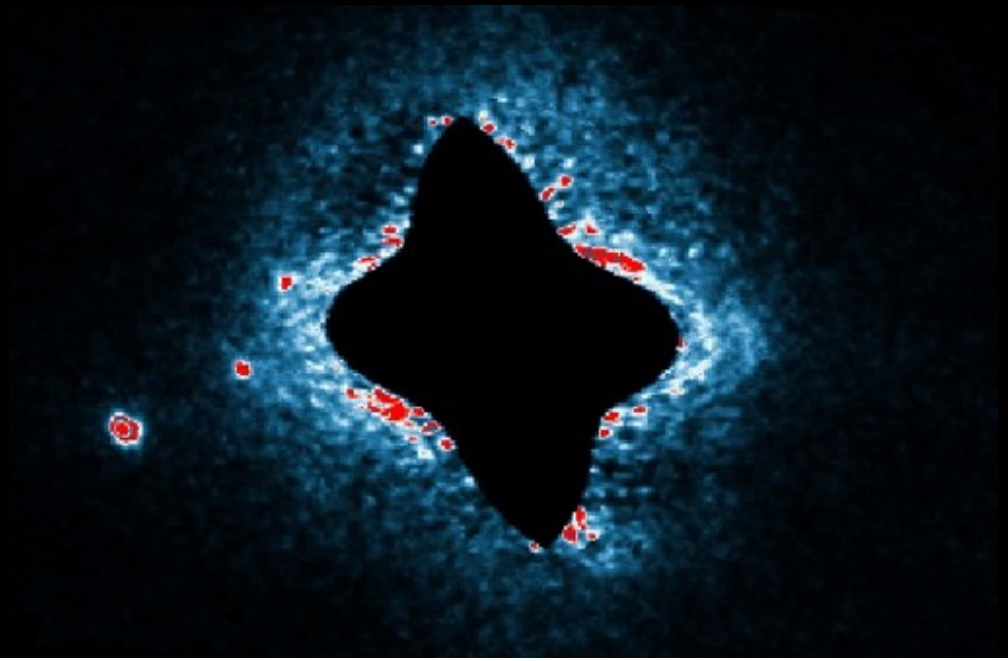
La (première) détection depuis le sol des arcs de Neptune

Bruno Sicardy
Sorbonne Université et Observatoire de Paris/LTE

“Le tourbillon de la vie“ journées François Roddier
Observatoire de Paris 5-6 juin 2025



Nature **319** (20 Feb. 1986)

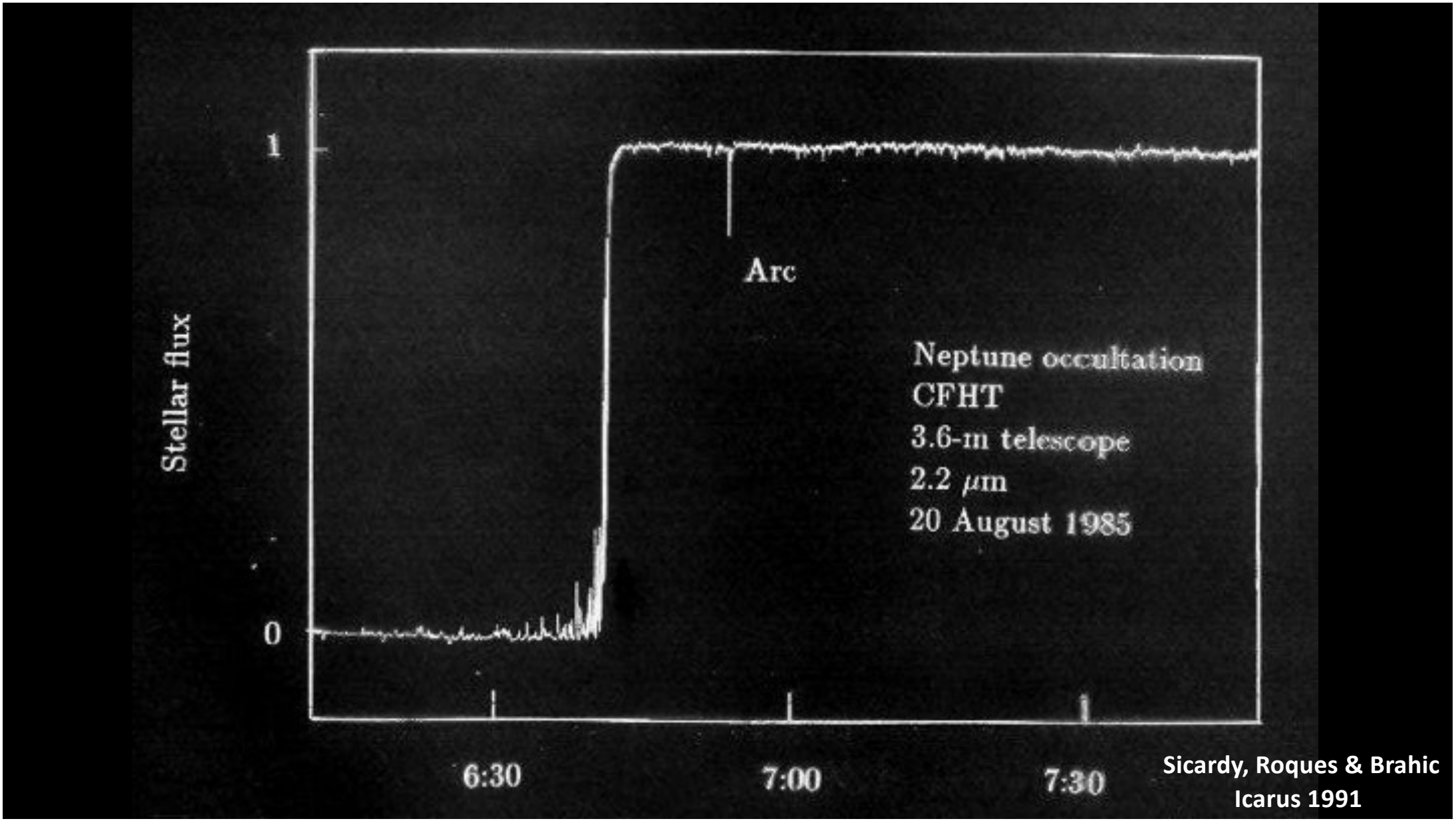
ARTICLES

Occultation detection of a neptunian ring-like arc (22 July 1984)

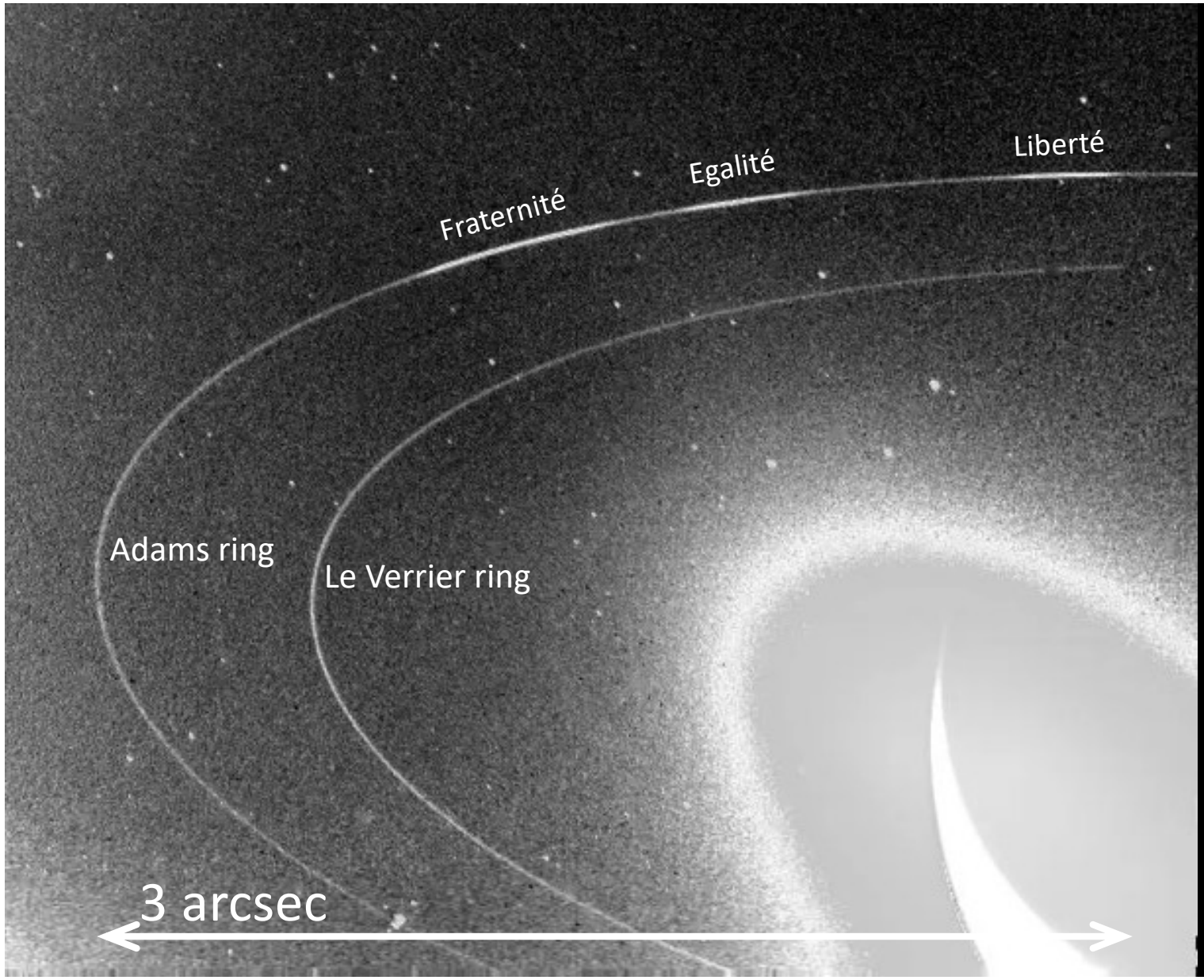
W. B. Hubbard*, A. Brahic†, B. Sicardy†, L.-R. Elicer‡, F. Roques† & F. Vilas*§

* Lunar and Planetary Laboratory, University of Arizona, Tucson, Arizona 85721, USA
† Université Paris VII, Observatoire de Paris, 92190 Meudon, France
‡ Cerro Tololo Inter-American Observatory, Casilla 603, La Serena, Chile

The apparent closest approach of the star SAO186001 to Neptune was observed photoelectrically on 22 July 1984 at Cerro Tololo Inter-American Observatory. A 32% signal drop lasting about 1.2 s was probably caused by a partially transparent arc of material at a distance of 67,000 km from Neptune. Neptune's arc(s) do not vary smoothly with azimuth, unlike the rings of other jovian planets.



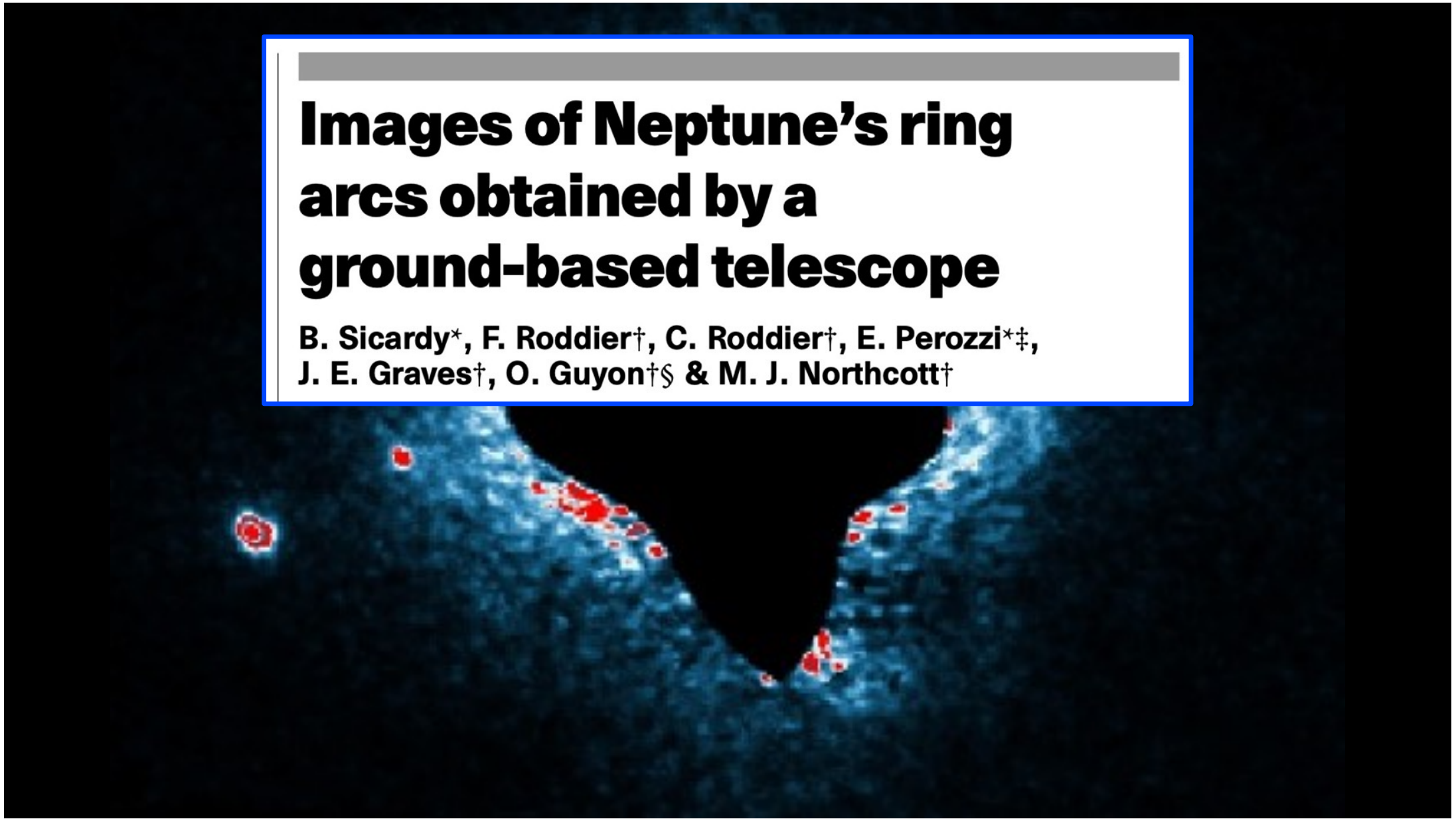
Sicardy, Roques & Brahic
Icarus 1991



Neptune's Adams ring:
a surprise, highly
variable in longitude!

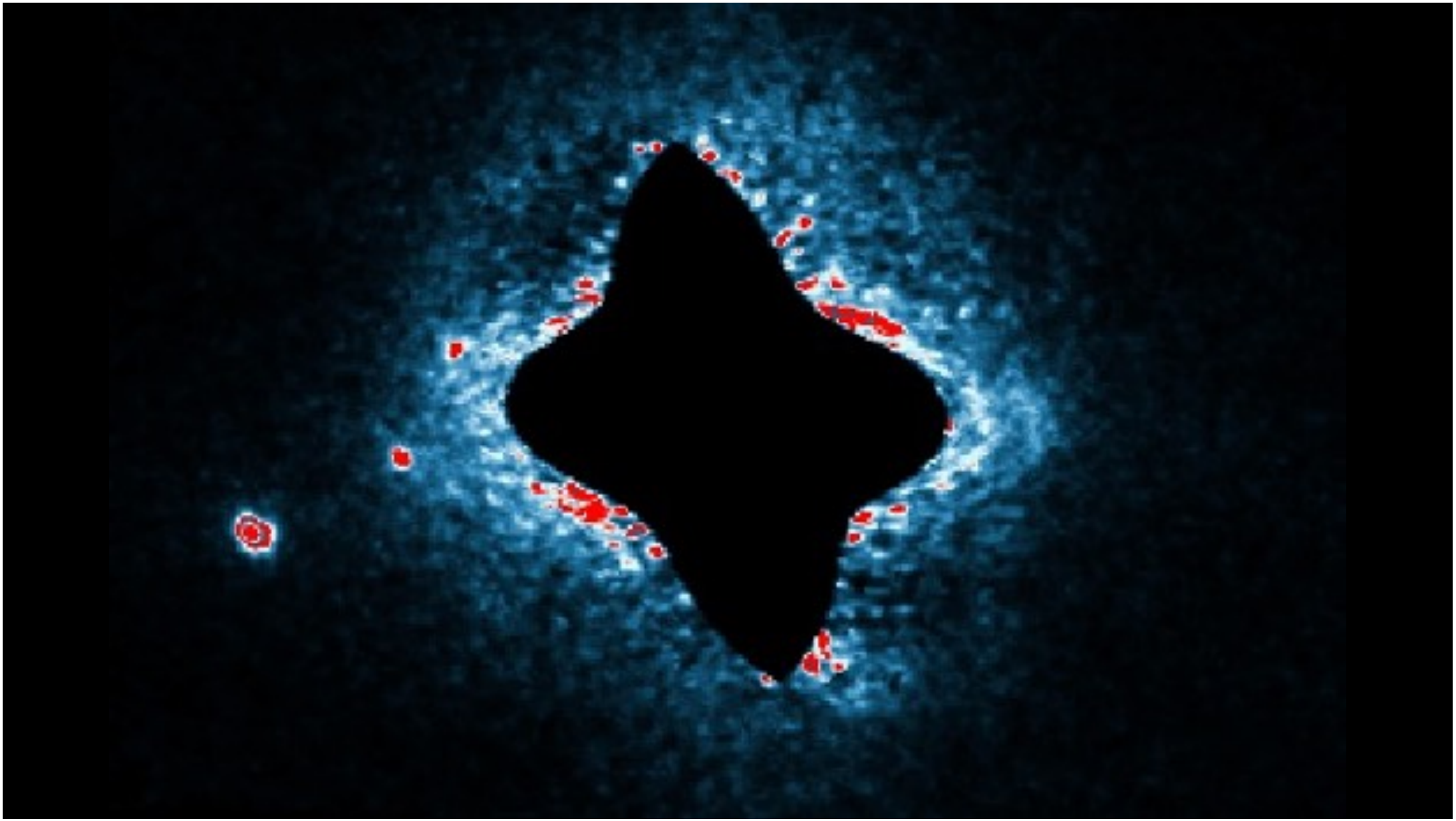
NASA/Voyager
August 1989

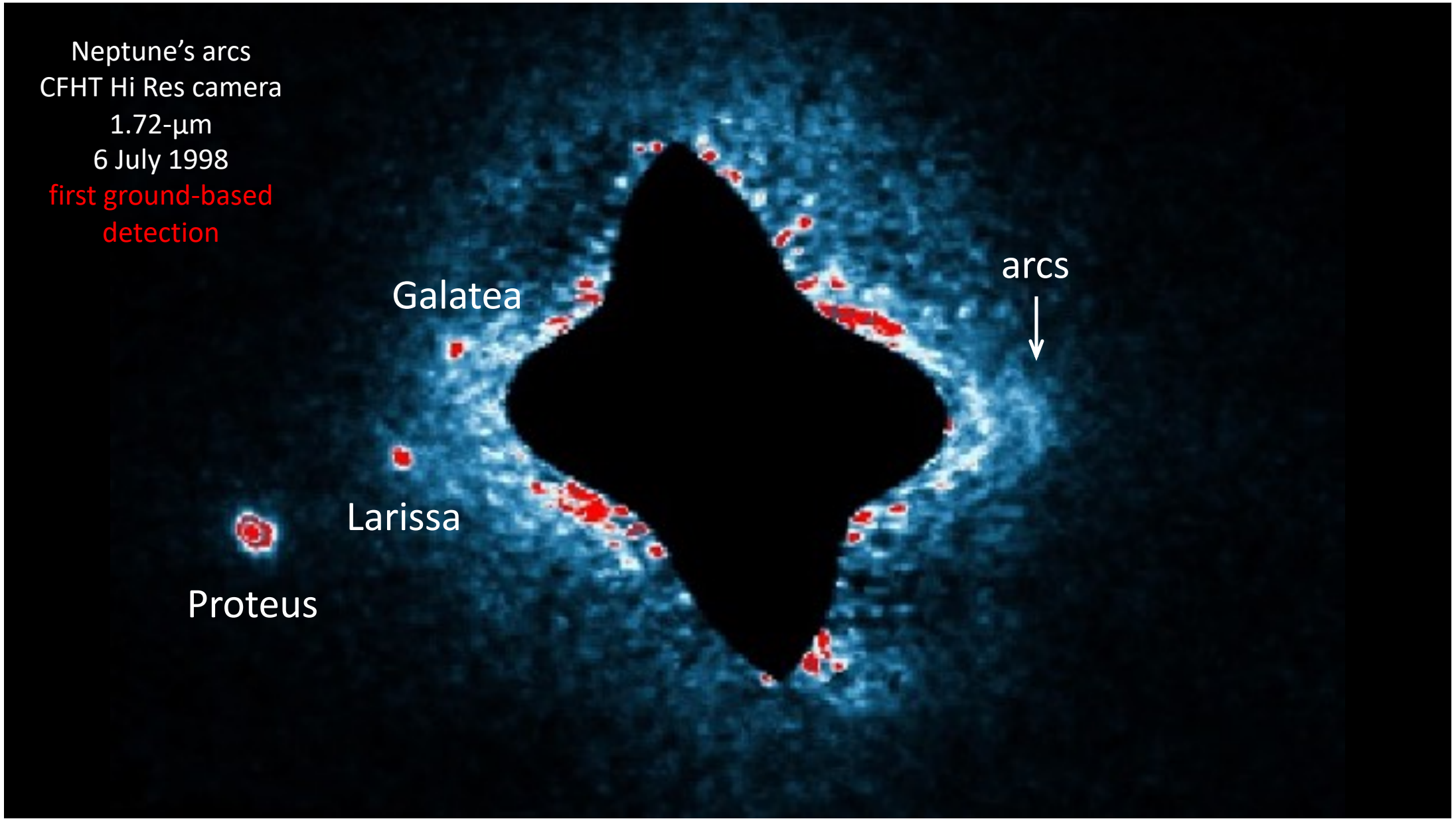
19 August 1999



Images of Neptune's ring arcs obtained by a ground-based telescope

B. Sicardy*, F. Roddier†, C. Roddier†, E. Perozzi*‡,
J. E. Graves†, O. Guyon†§ & M. J. Northcott†

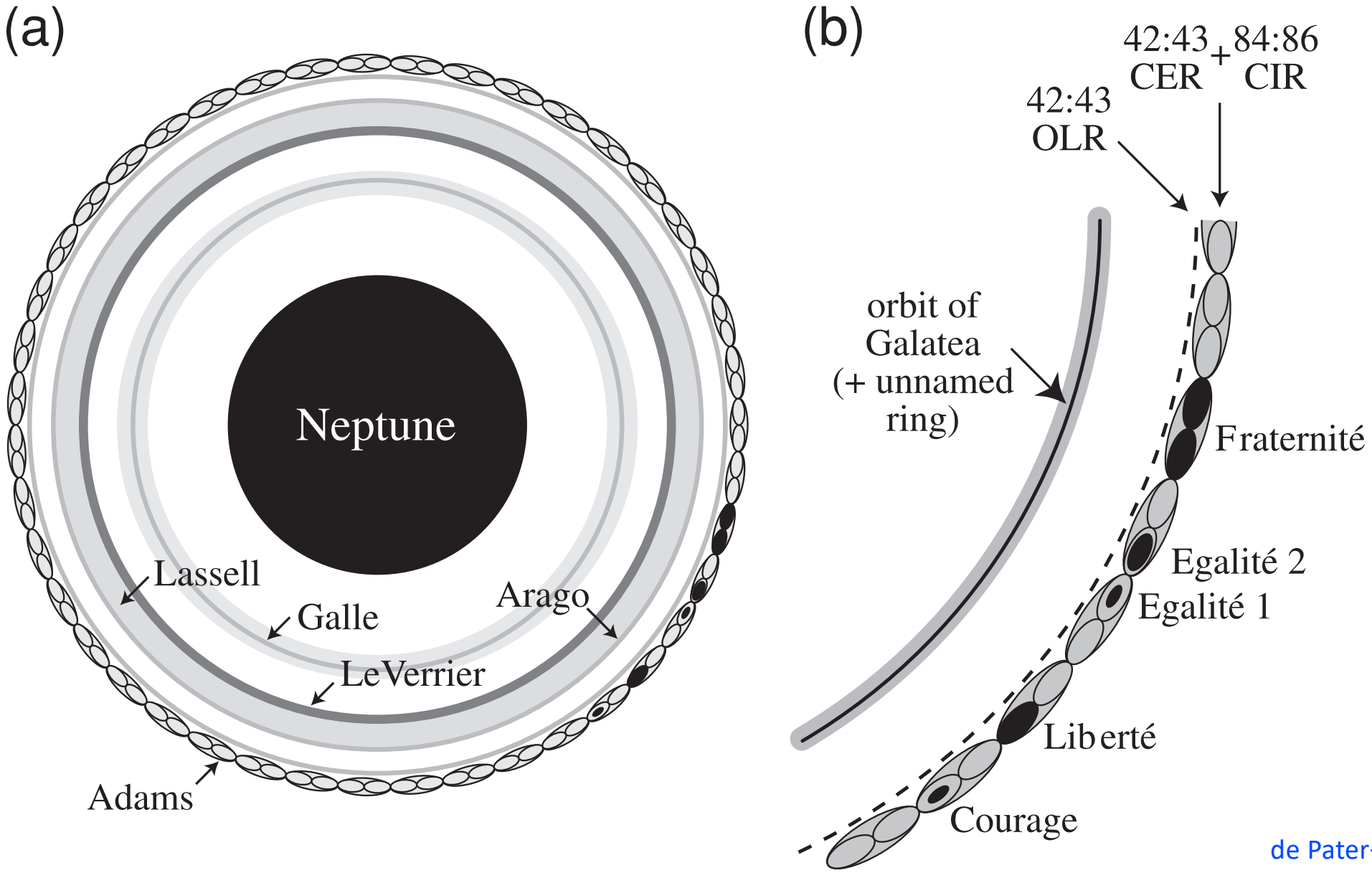


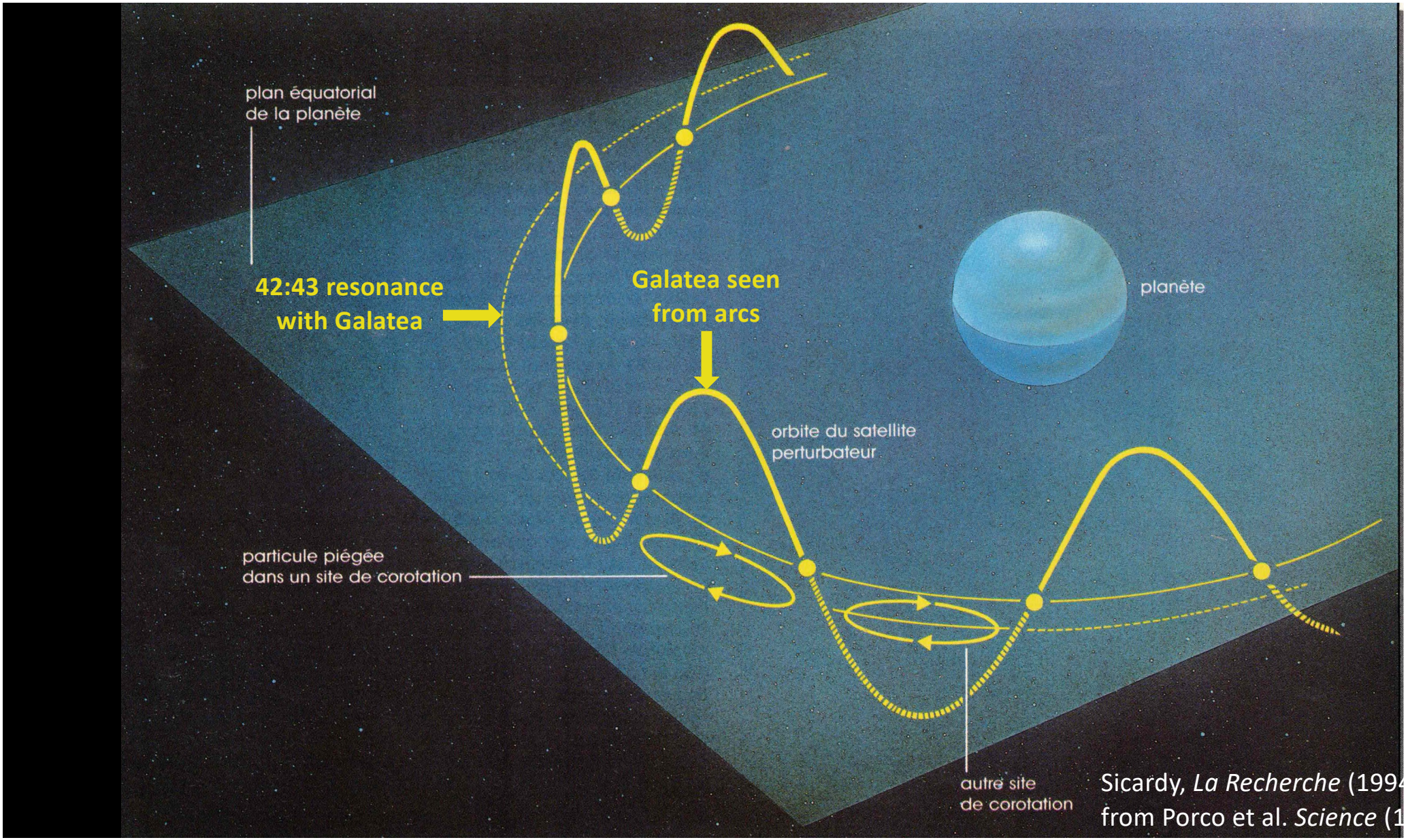

Neptune's arcs
CFHT Hi Res camera
1.72-µm
6 July 1998
first ground-based
detection
Galatea
arcs
Larissa
Proteus

If left free, should be destroyed in a few months

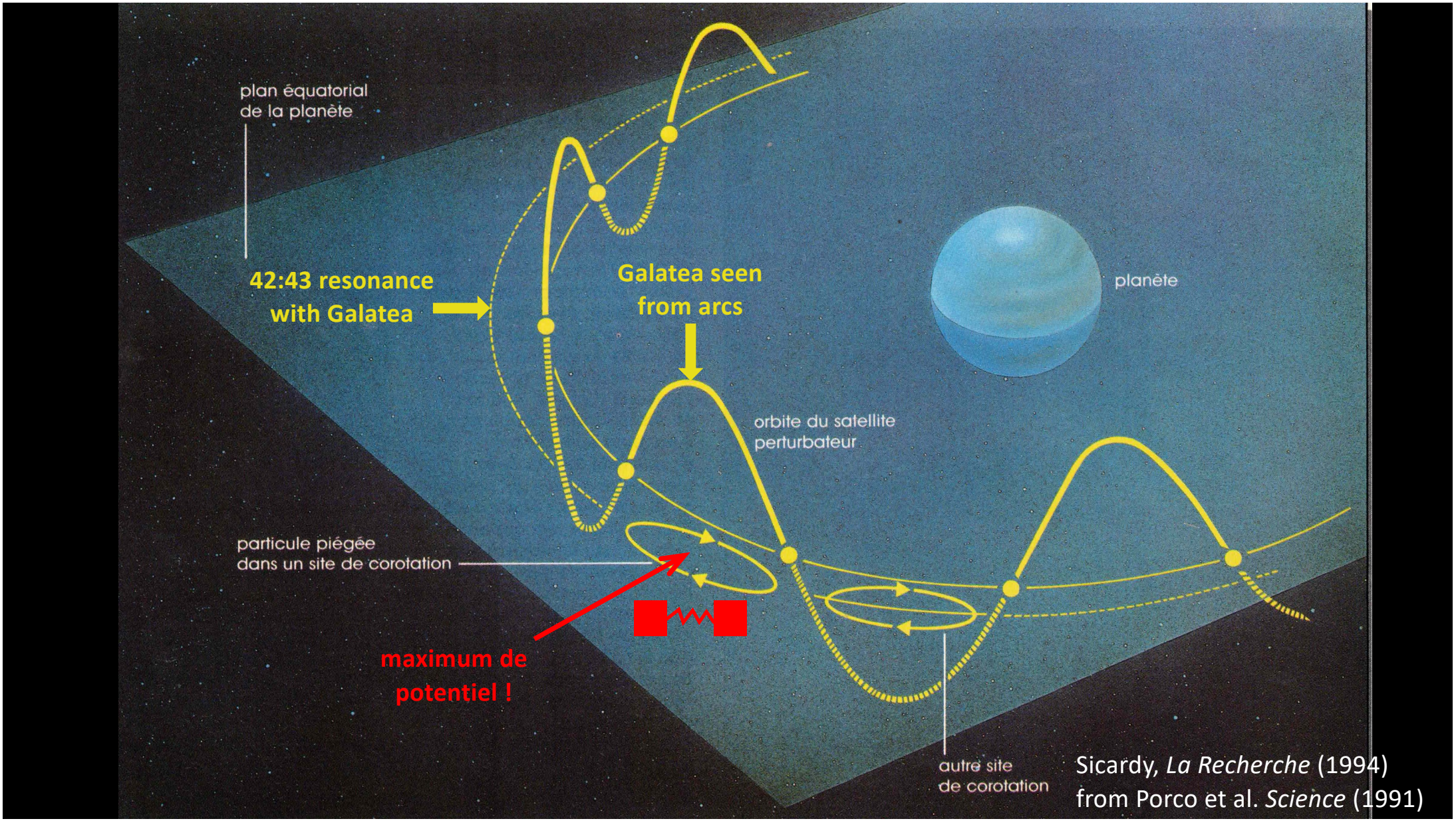
Keeping material confined radially and azimuthally is a challenge

Interest: is it an intermediate step between a “fluid” ring and a “solid” accreted body? i.e. a route to satellite formation?

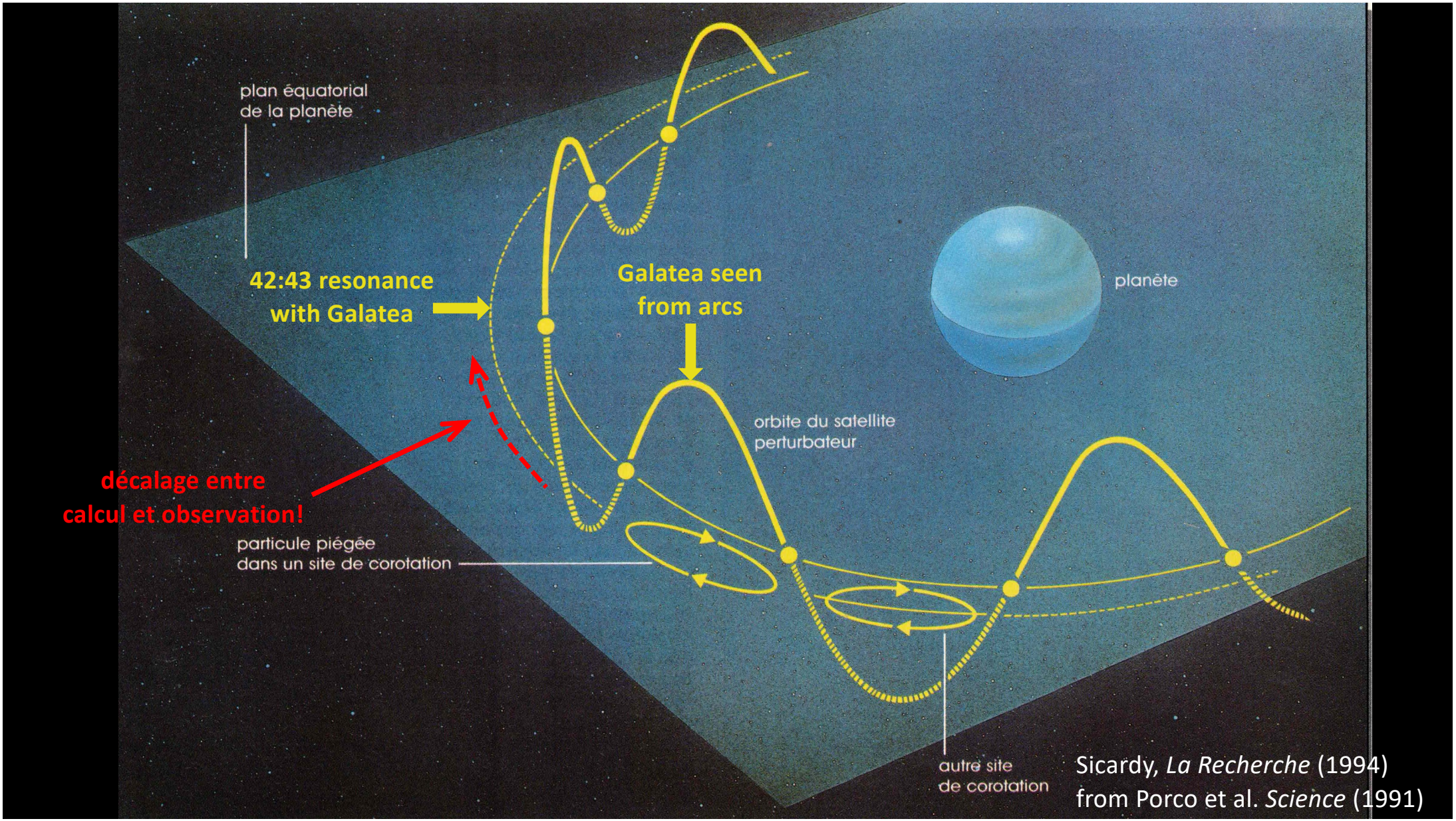

(a)
Neptune
Lassell
Galle
LeVerrier
Arago
Adams
(b)
42:43 + 84:86
CER CIR
42:43
OLR
orbit of
Galatea
(+ unnamed
ring)
Fraternité
Egalité 2
Egalité 1
Liberté
Courage
de Pater+ 2018



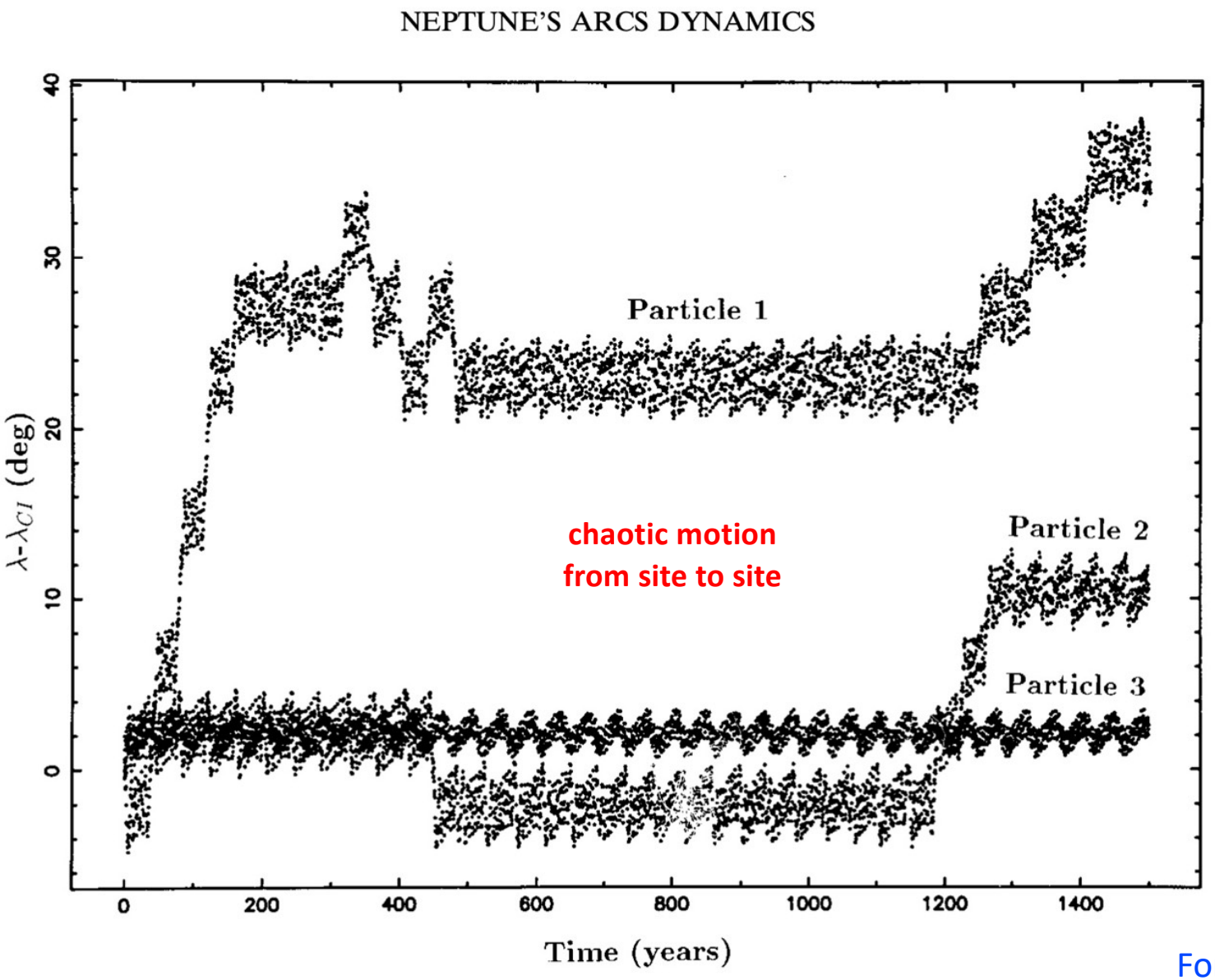
Sicardy, *La Recherche* (199
from Porco et al. *Science* (1



Sicardy, *La Recherche* (1994)
from Porco et al. *Science* (1991)



Sicardy, *La Recherche* (1994)
from Porco et al. *Science* (1991)



Foryta & Sicardy 1996

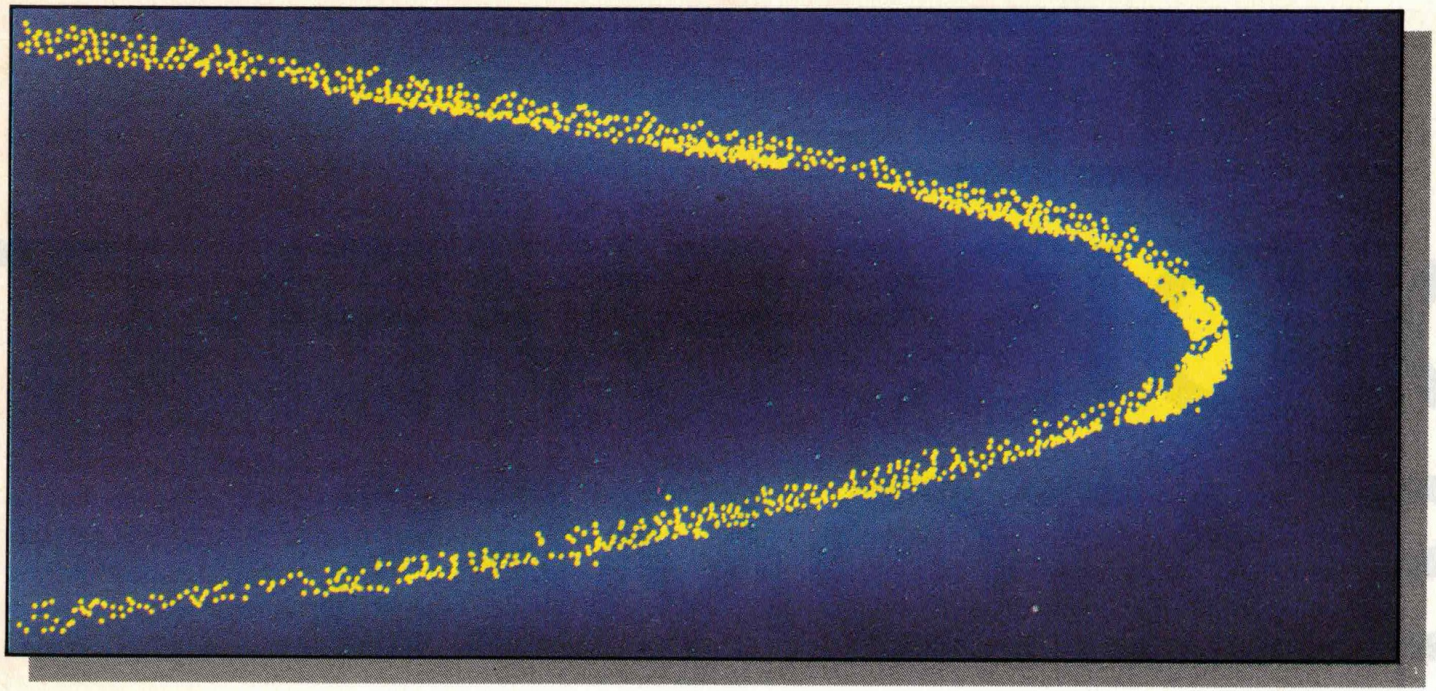
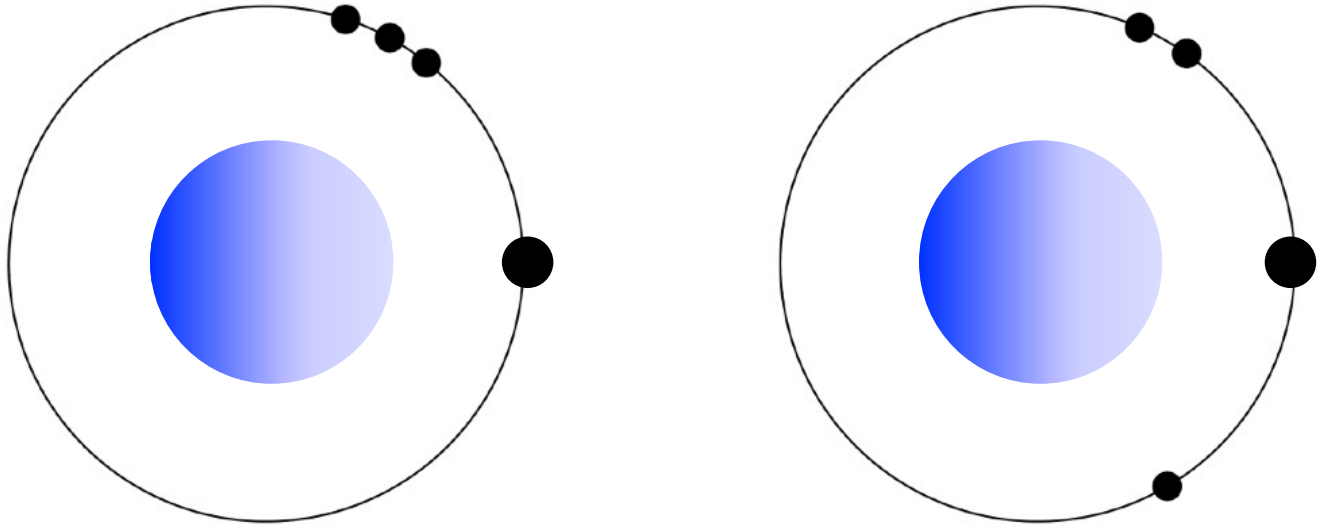


Figure 5. Comment évolueraient dix mille particules, relâchées initialement depuis un point unique au voisinage de Neptune avec des vitesses légèrement différentes, puis soumises aux perturbations du satellite Galatéa ? Cette simulation réalisée à l'Observatoire de Paris illustre leur comportement après quarante mille révolutions, soit cinq cents ans plus tard. L'anneau simulé est vu sous un angle de visée de 2,5°. Beaucoup de particules se trouvent encore dans le site de corotation initial où les a piégées le mouvement vertical de Galatéa. Certaines ont en revanche pu diffuser dans des sites adjacents. D'autres enfin forment un anneau continu plus diffus. (Simulation effectuée par D.W. Foryta[13]).

Sicardy 1994
Foryta & Sicardy 1996

a possible explanation of Neptune's arcs distribution: co-orbital satellites

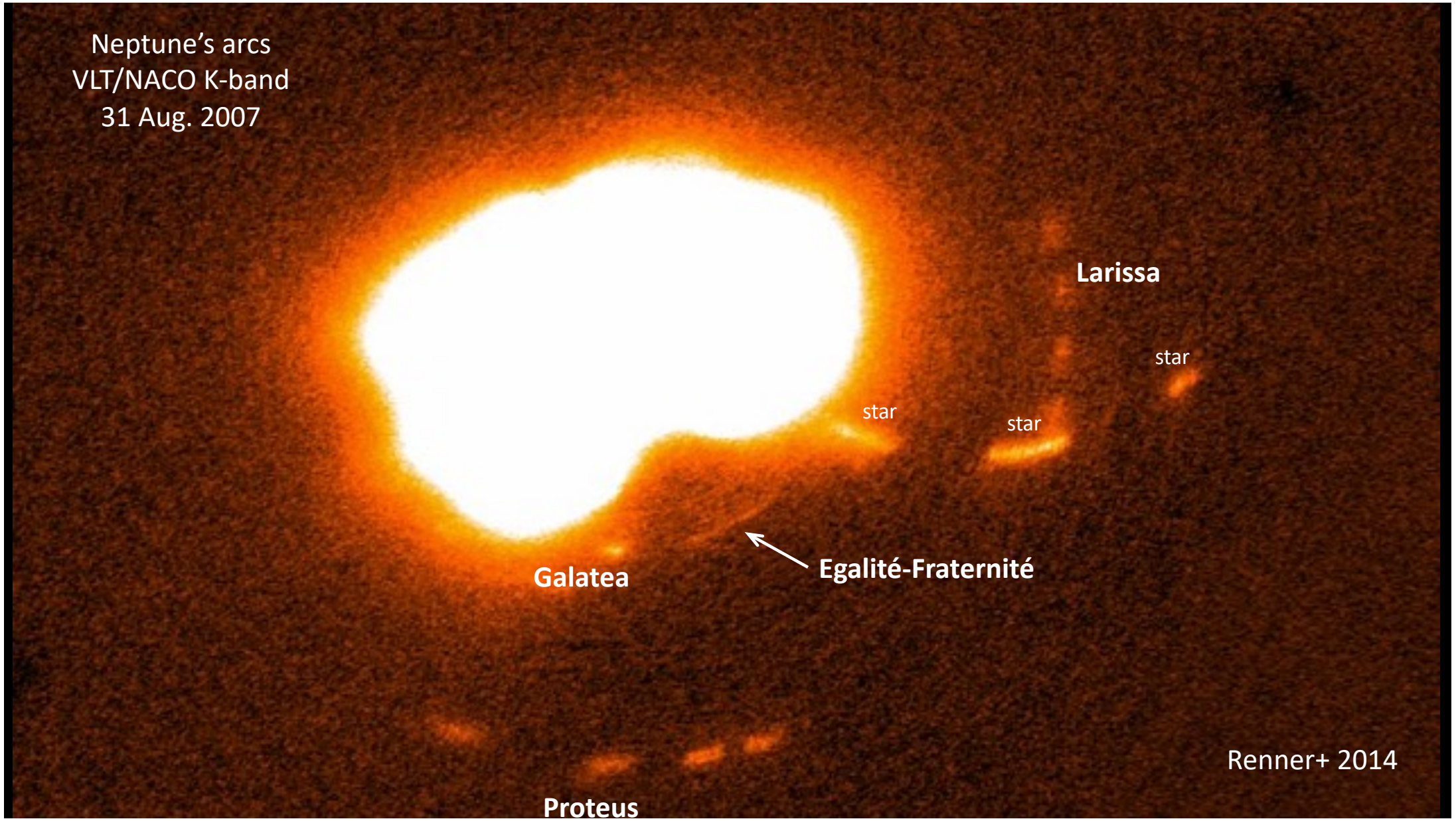


STATIONARY CONFIGURATIONS FOR CO-ORBITAL SATELLITES WITH SMALL ARBITRARY MASSES

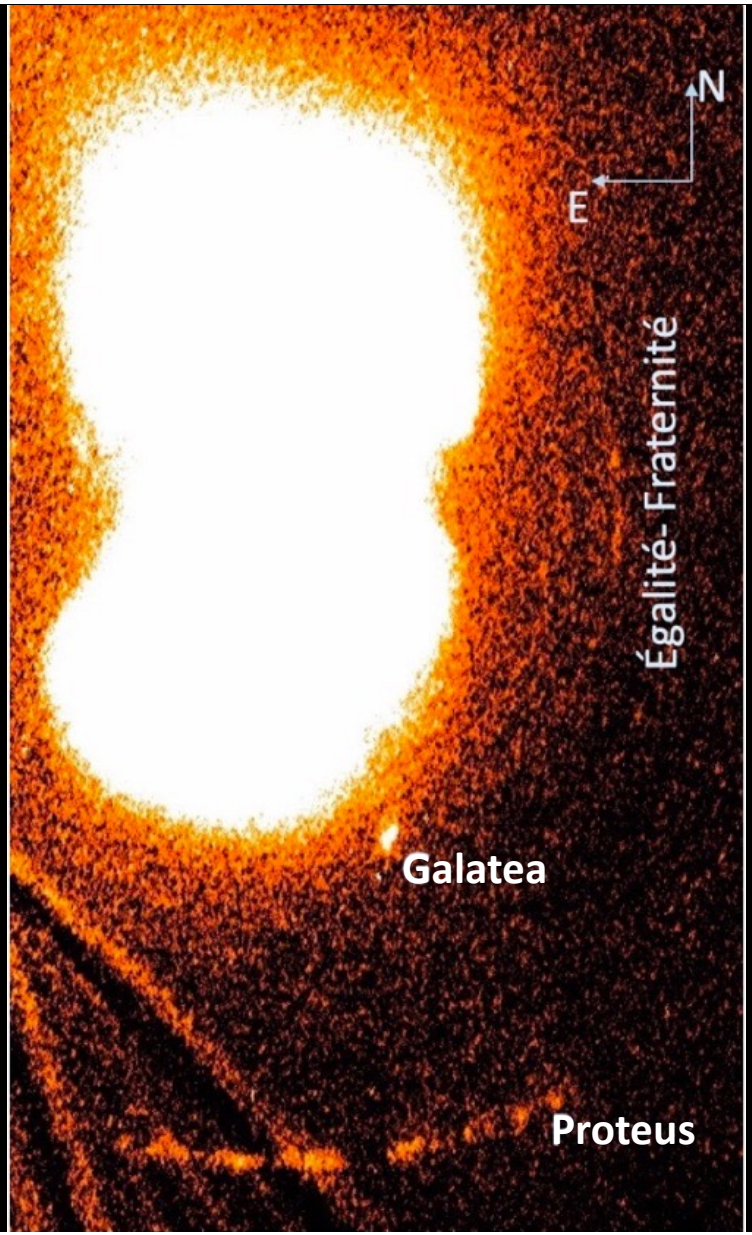
Cel'Mec (2004)

STÉFAN RENNER and BRUNO SICARDY

LESIA, Observatoire de Paris, 92195 Meudon Cédex, France, e-mail: stefan.renner@obspm.fr


Neptune's arcs
VLT/NACO K-band
31 Aug. 2007
Larissa
star
star
star
Galatea
Egalité-Fraternité
Renner+ 2014
Proteus

Neptune’s arcs
Sphere/NACO K-band
23 Aug. 2016



Souami+ 2022

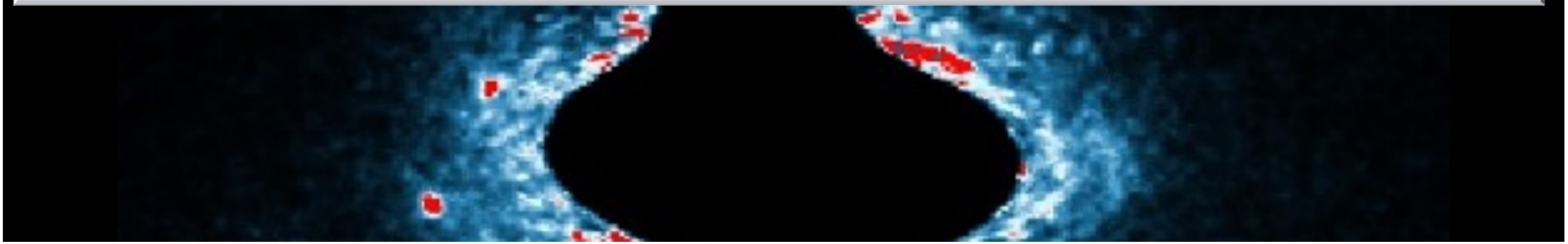
Conclusions

Observations to date show that the arcs are not fully locked in the corotation sites created by Galatea

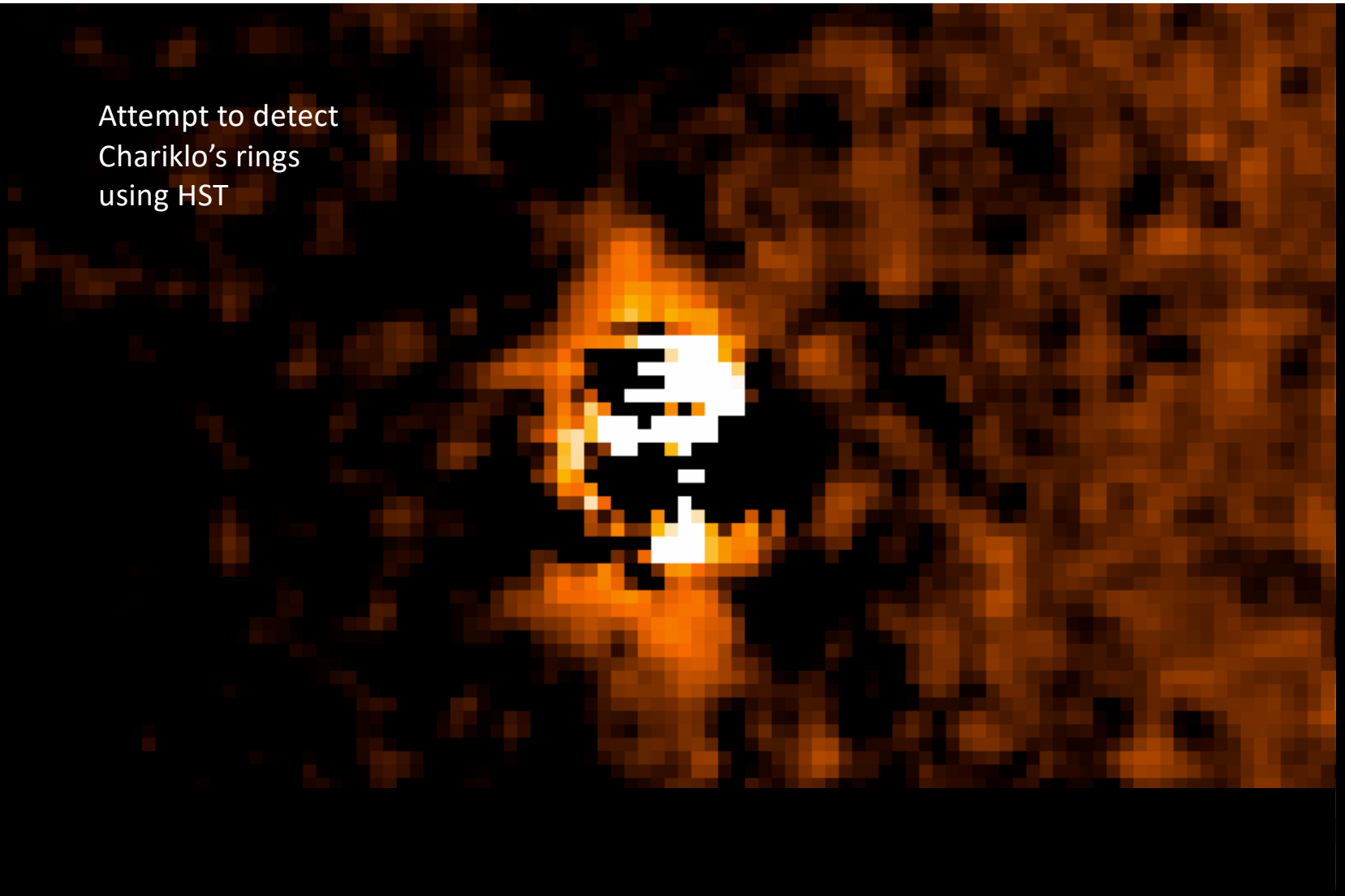
Arcs may follow a chaotic “leapfrog motion” from site to site

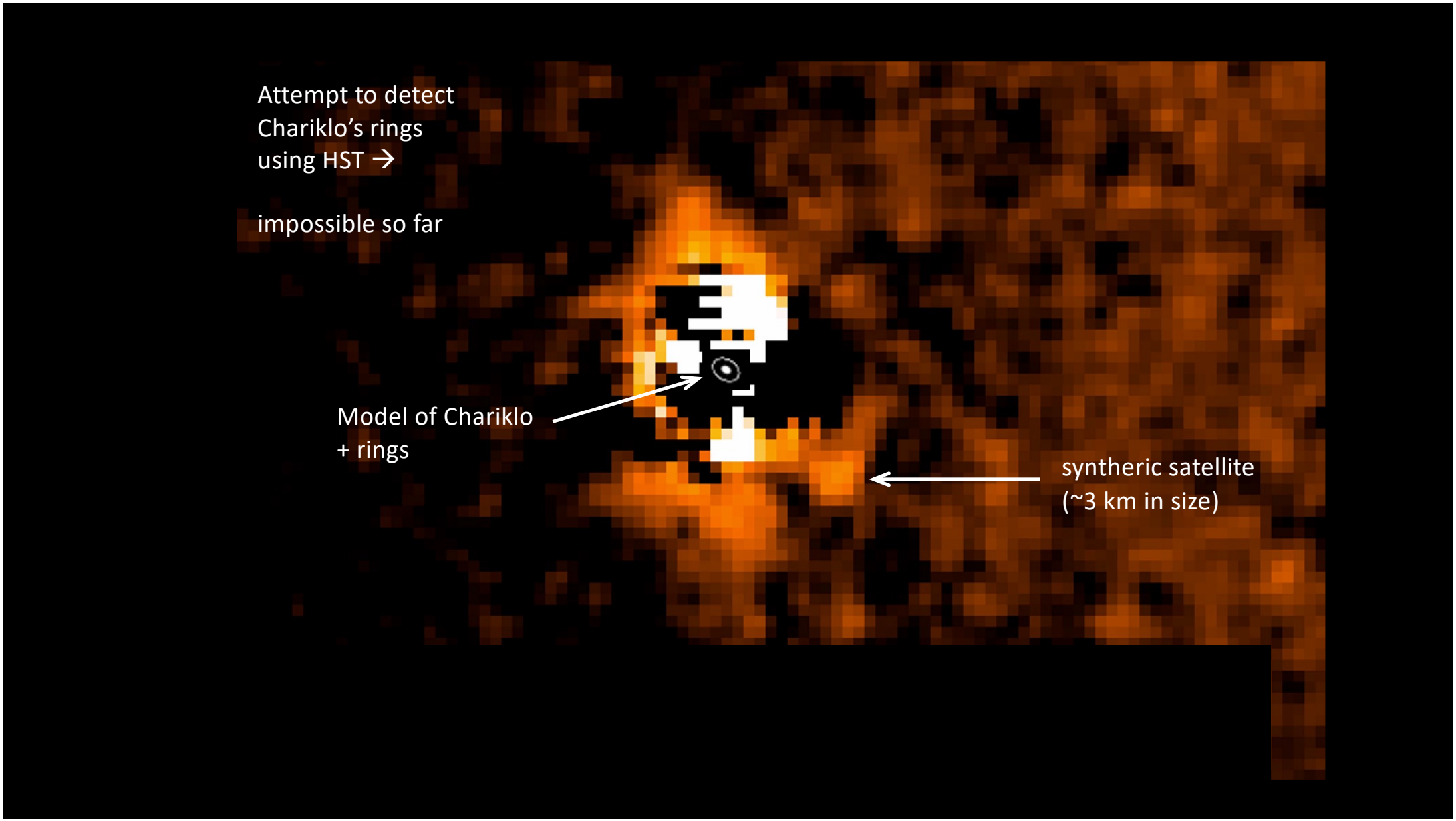
Arcs might be bouncing back and forth between (still) unseen small satellites co-orbital with arcs

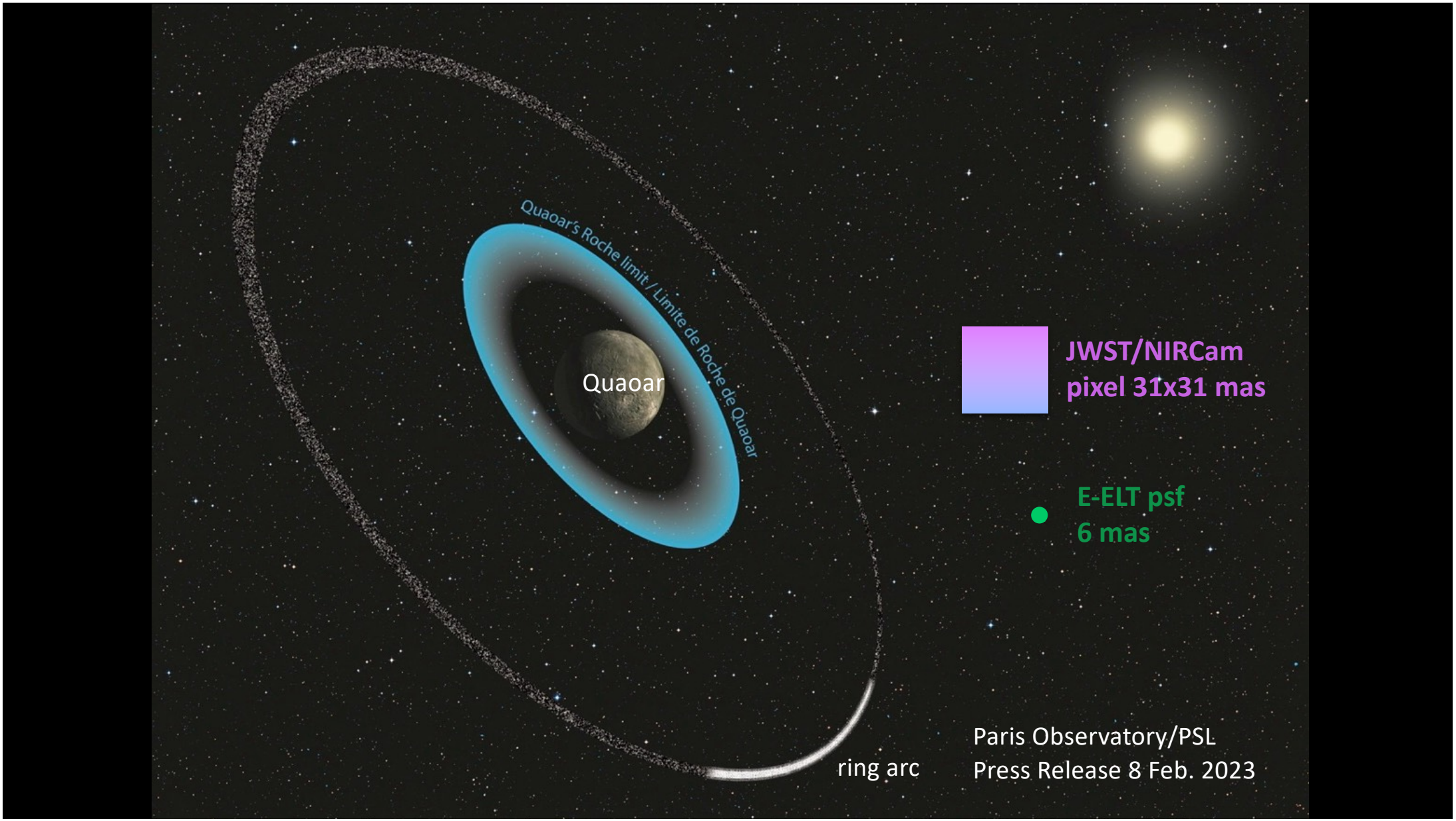
Other ring arcs are observed around small objects of the solar system…

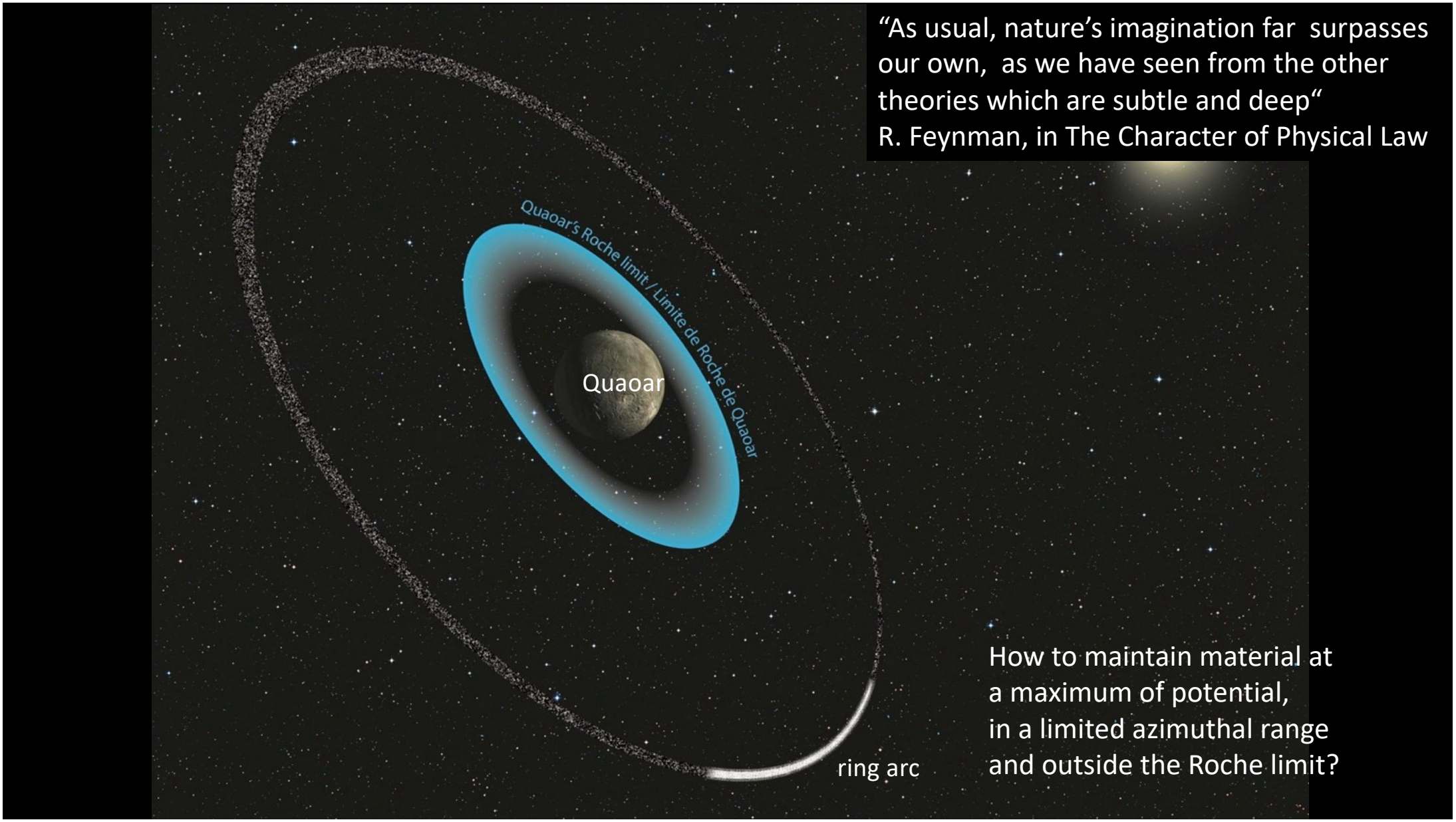


Attempt to detect
Chariklo's rings
using HST




Attempt to detect
Chariklo's rings
using HST →
impossible so far
Model of Chariklo
+ rings
syntheric satellite
(~3 km in size)


Quaoar's Roche limit / Limite de Roche de Quaoar
Quaoar
JWST/NIRCam
pixel 31x31 mas
E-ELT psf
6 mas
ring arc
Paris Observatory/PSL
Press Release 8 Feb. 2023



"As usual, nature's imagination far surpasses our own, as we have seen from the other theories which are subtle and deep"
R. Feynman, in The Character of Physical Law

How to maintain material at a maximum of potential, in a limited azimuthal range and outside the Roche limit?