IRAP/OMP, CNRS, Université Paul Sabatier de Toulouse,
Institut universitaire de France

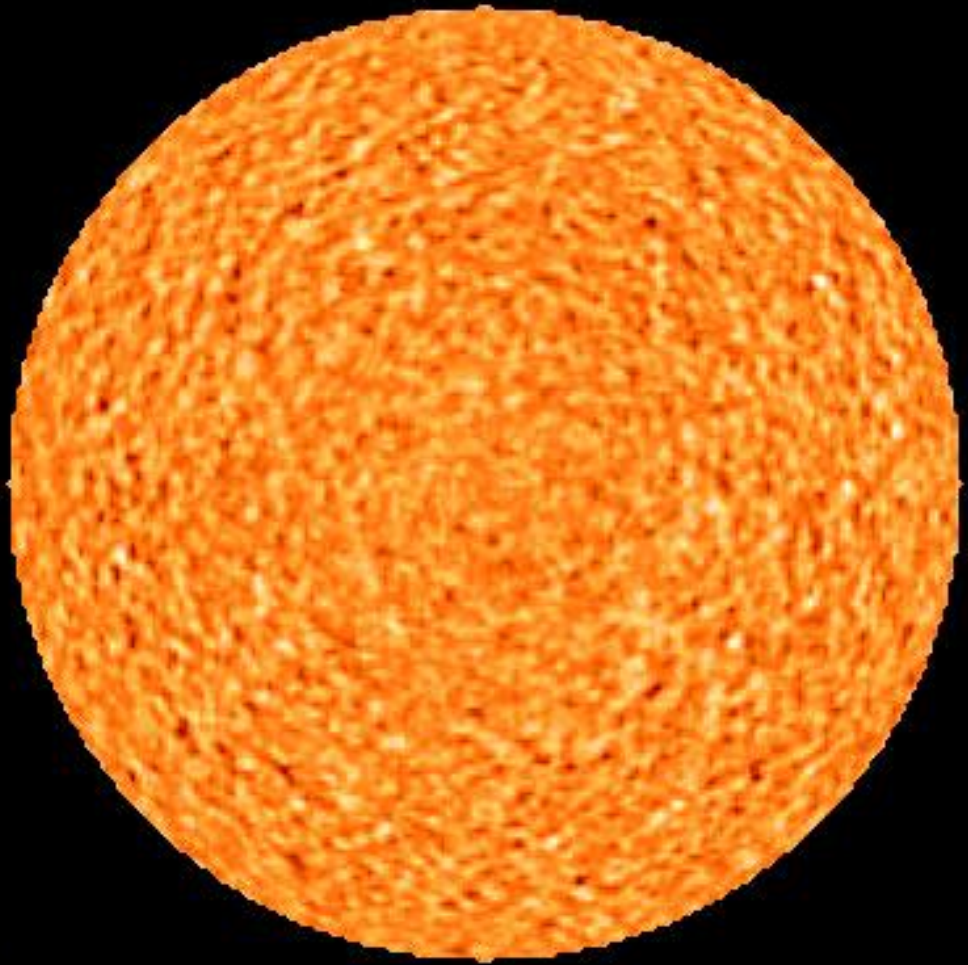
La musique des étoiles

Sylvie Vauclair
musiques de Claude-Samuel Levine

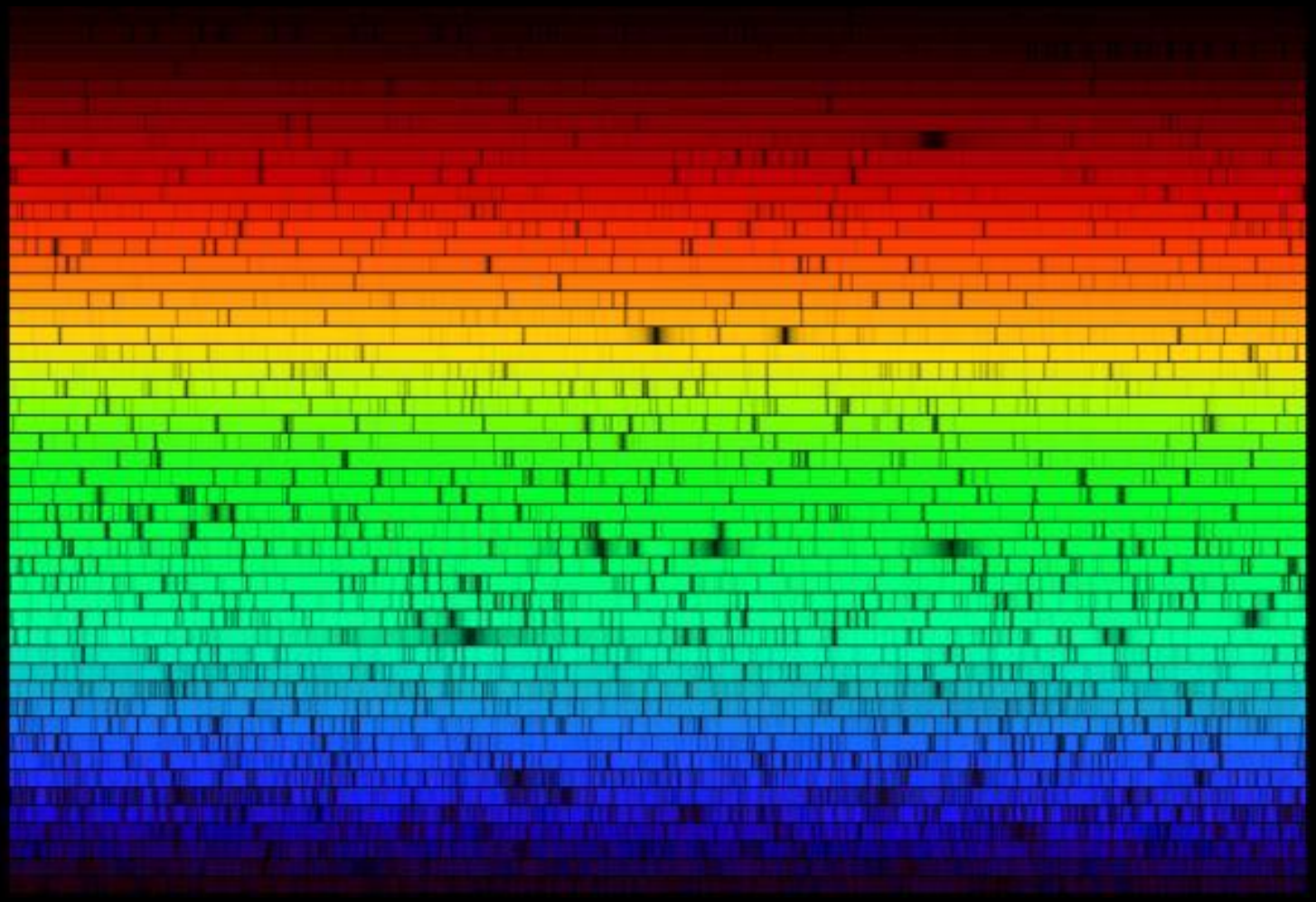
7 août 2014

Festival d'astronomie de Fleurance

Vibrations solaires très amplifiées



Soleil : R = 700 000 km, période 5mn



Spectre optique du Soleil

VELOCITY FIELDS IN THE SOLAR ATMOSPHERE
I. PRELIMINARY REPORT*

ROBERT B. LEIGHTON, ROBERT W. NOYES, AND GEORGE W. SIMON
California Institute of Technology, Pasadena, California
Received October 16, 1961

ABSTRACT

Velocity fields in the solar atmosphere have been detected and measured by an adaptation of a technique previously used for measuring magnetic fields Data obtained during the summers of 1960 and 1961 have been partially analyzed and yield the following principal results:

1. Large "cells" of horizontally moving material are distributed roughly uniformly over the entire solar surface. The motions within each cell suggest a (horizontal) outward flow from a source inside the cell. Typical diameters are 1.6×10^4 km; spacings between centers, 3×10^4 km ($\sim 5 \times 10^3$ cells over the solar surface); r.m s. velocities of outflow, 0.5 km sec^{-1}; lifetimes, 10^4–10^5 sec. There is a similarity in appearance to the Ca^+ network. The appearance and properties of these cells suggest that they are a surface manifestation of a "supergranulation" pattern of convective currents which come from relatively great depths inside the sun.

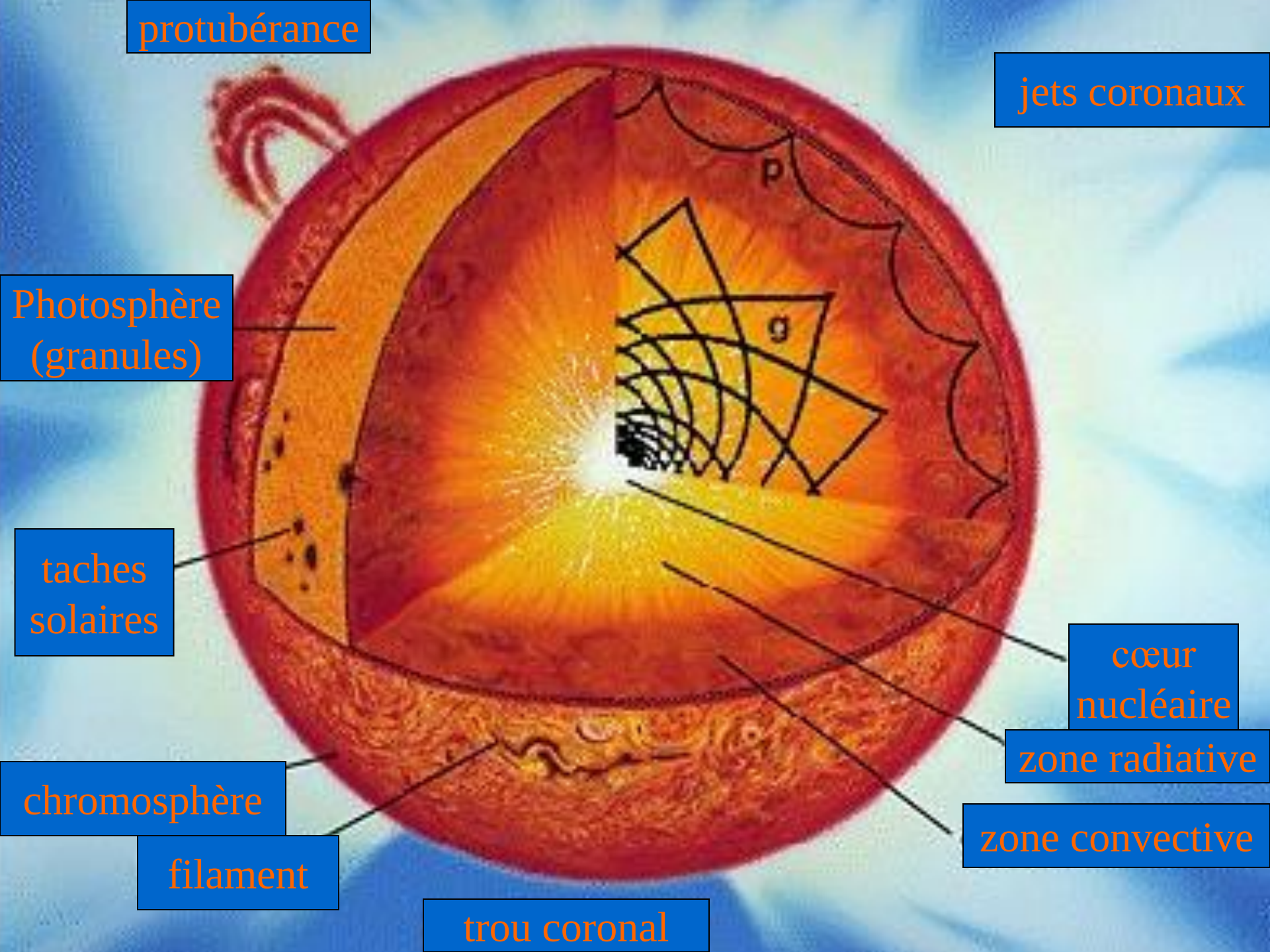
2. A distinct correlation is observed between local brightness fluctuations and vertical velocities: bright elements tend to move upward, at the levels at which the lines Fe λ 6102 and Ca λ 6103 are formed. In the line Ca λ 6103, the correlation coefficient is ~0.5. This correlation appears to reverse in sign in the height range spanned by the Doppler wings of the Na D_1 line and remains reversed at levels up to that of Ca^+ λ 8542. At the level of Ca λ 6103, an estimate of the mechanical energy transport yields the rather large value 2 W cm^{-2}.

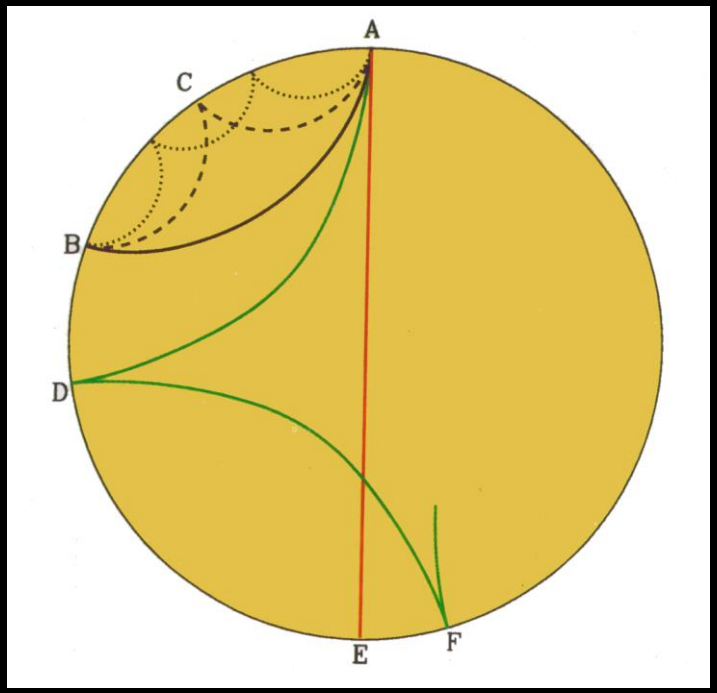
3. The characteristic "cell size" of the vertical velocities appears to increase with height from ~1700 km at the level of Fe λ 6102 to ~3500 km at that of Na λ 5896. The r.m s. vertical velocity of ~0 4 km sec^{-1} appears nearly constant over this height range.

4. The vertical velocities exhibit a striking repetitive time correlation, with a period $T = 296 \pm 3$ sec. This quasi-sinusoidal motion has been followed for three full periods in the line Ca λ 6103, and is also clearly present in Fe λ 6102, Na λ 5896, and other lines. The energy contained in this oscillatory motion is about 160 J cm^{-2}; the "losses" can apparently be compensated for by the energy transport (2).

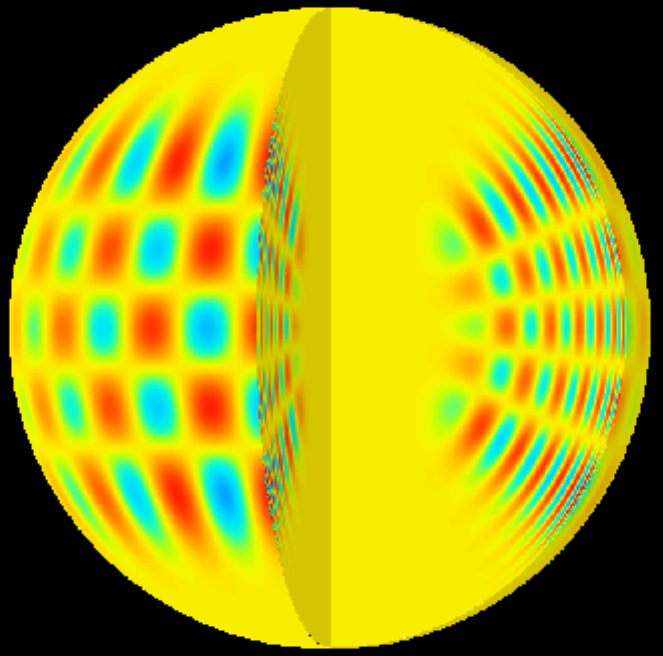
5. A similar repetitive time correlation, with nearly the same period, seems to be present in the *brightness fluctuations* observed on ordinary spectroheliograms taken at the center of the Na D_1 line. We believe that we are observing the transformation of potential energy into wave energy through the brightness-velocity correlation in the photosphere, the upward propagation of this energy by waves of rather well-defined frequency, and its dissipation into heat in the lower chromosphere.

6. Doppler velocities have been observed at various heights in the upper chromosphere by means of the Hα line. At great heights one finds a granular structure with a mean size of about 3600 km, but at lower levels one finds predominantly *downward* motions, which are concentrated in "tunnels" which presumably follow magnetic lines of force and are geometrically related to the Ca^+ network. The Doppler field changes its appearance *very rapidly* at higher levels, typical lifetimes being about 30 *seconds*.

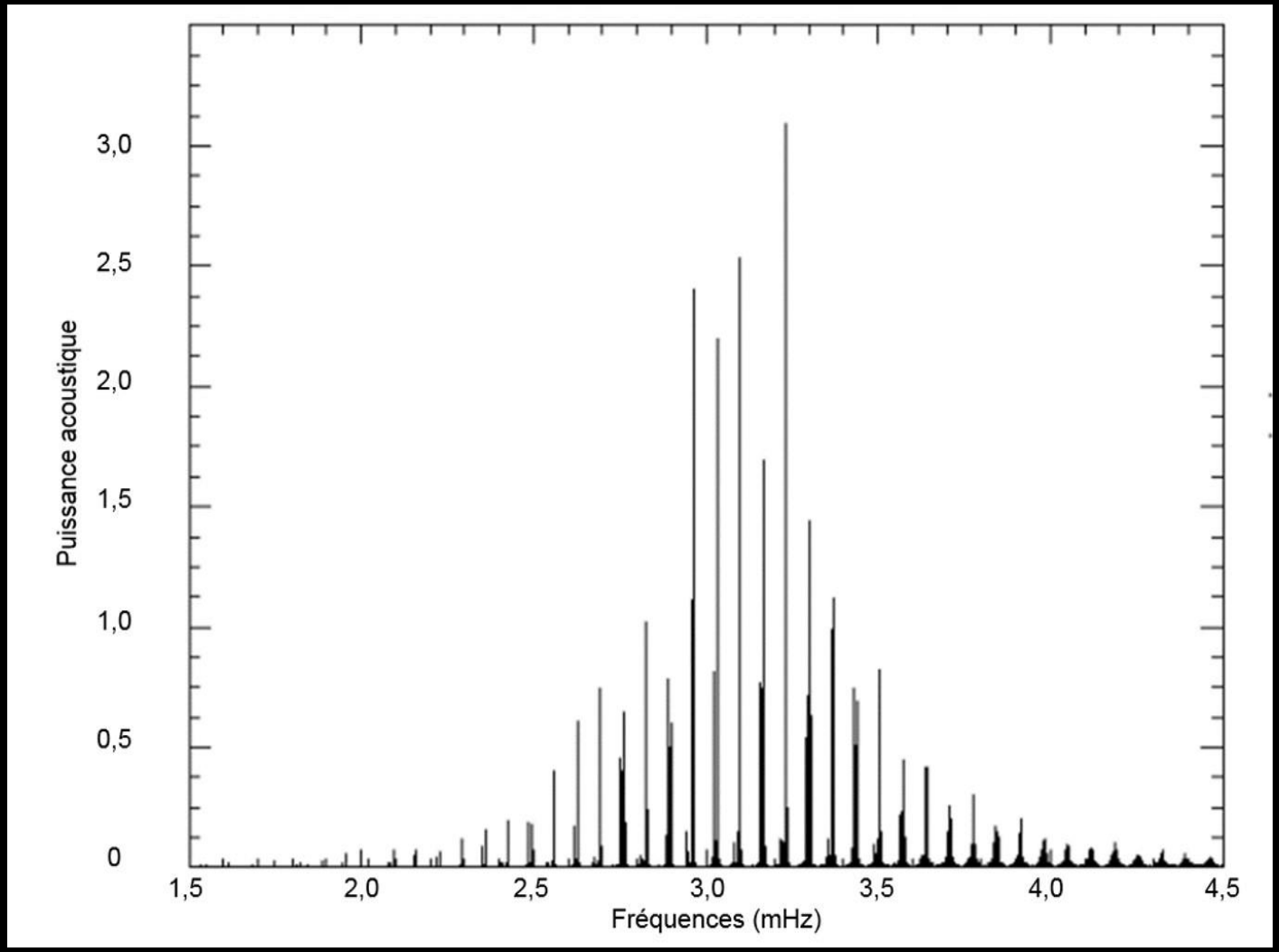

protubérance
jets coronaux
Photosphère (granules)
taches solaires
cœur nucléaire
zone radiative
chromosphère
zone convective
filament
trou coronal



Soleil :
plusieurs dizaines de millions
de modes détectés

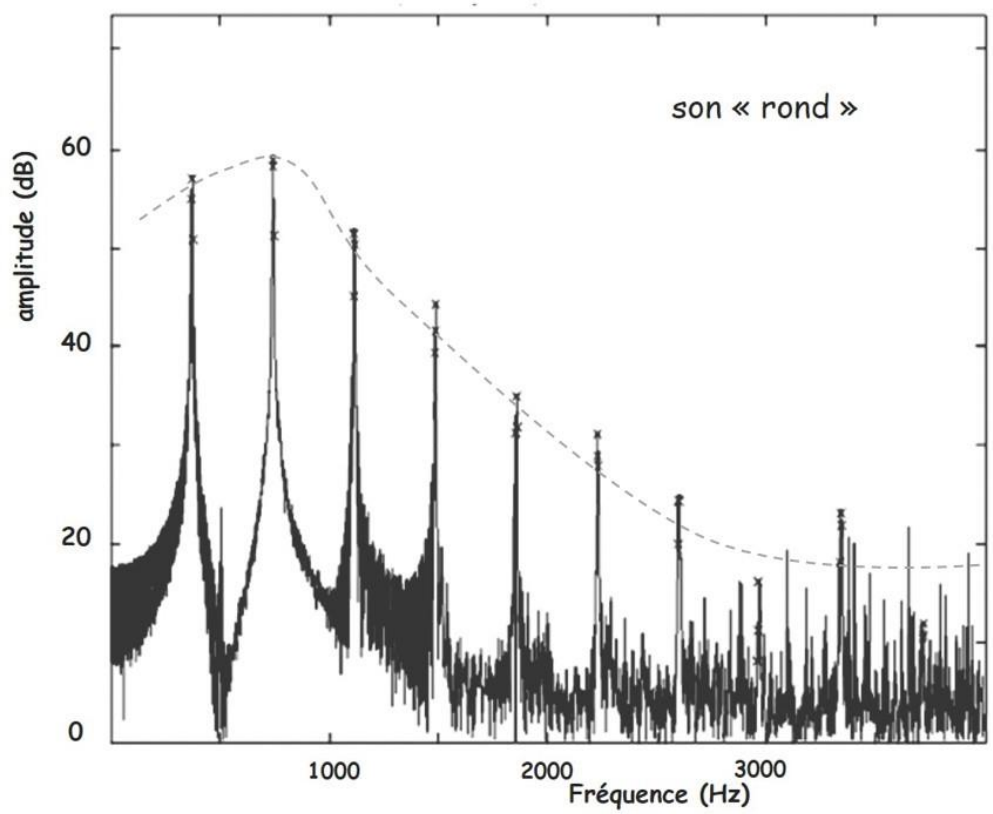


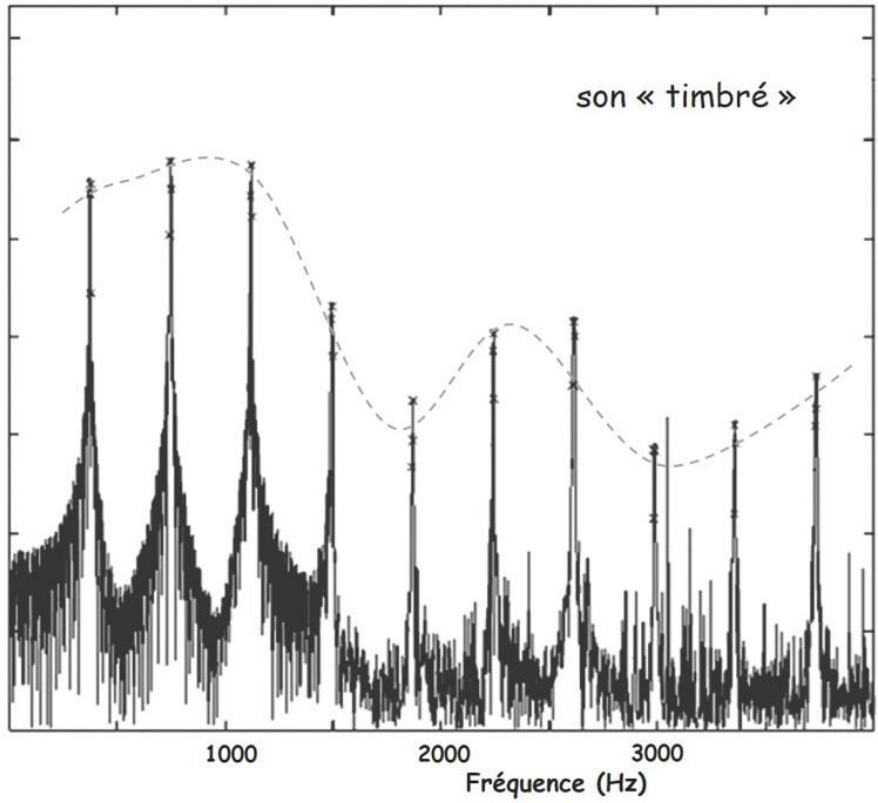
Etoiles :
plusieurs dizaines de modes
détectés !!!



Soleil: spectre acoustique

Sons d'une flute traversière (Fa)





Lancée le 2 décembre 1995
12 instruments à bord

Mauna Loa

Big Bear

Udaipur

a sun that …

does not set !

Learmonth

Cerro Tololo

El Teide

SOPHIE @ OHP

The HARPS Spectrograph and the 3.6m Telescope

ESO PR Photo 25a/04 (25 August 2004)

HARPS @ La Silla

(High Accuracy Radial velocity Planet Searcher)

Top left : dome of the 3m60 telescope;
right : the telescope inside the dome

Bottom : the HARPS spectrograph during laboratory tests


27 déc 2006
Corot
CNES
600kg ; 4,2 x 1,9m ; 530W ;
Mission nominale : 2.5 ans, extension : 3 ans
Intrument : miroir 27cm
Deux plans focaux : 1 pour les champs exoplanètes
1 pour les champs sismologie
4 cameras CCD; Grism devant les champs exoplanètes
Orbite polaire à 900km

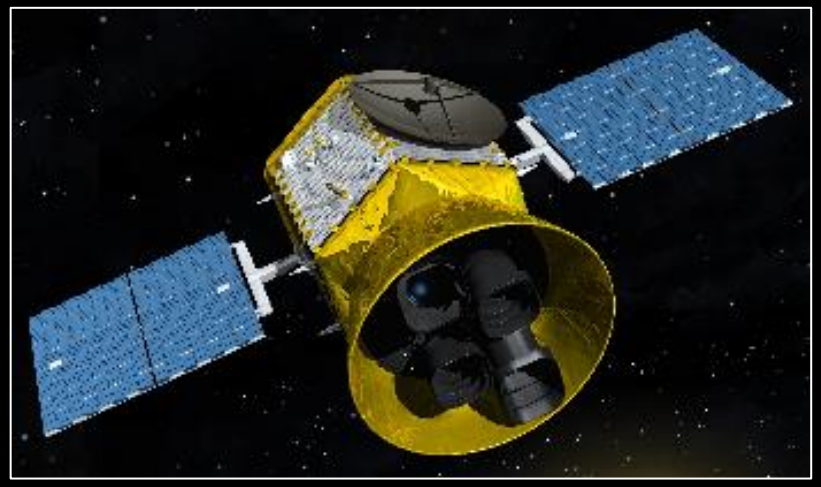
7 mars 2009

Kepler

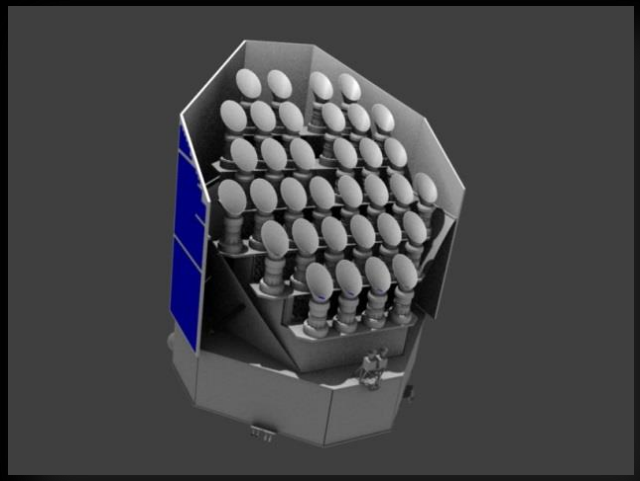
NASA

1039kg ; 4,2 x 1,9m ; 651 W ;
Mission nominale : 3 ans

Intrument : miroir 1,4m
Champ: 105 deg carrés
Orbite héliocentrique



The Transiting Exoplanet Survey Satellite (TESS) 2017?



PLATO (one possible design) 2024?


De l'ancienne
à la nouvelle musique des sphères

Pythagore : 560-490 av J-C (?)

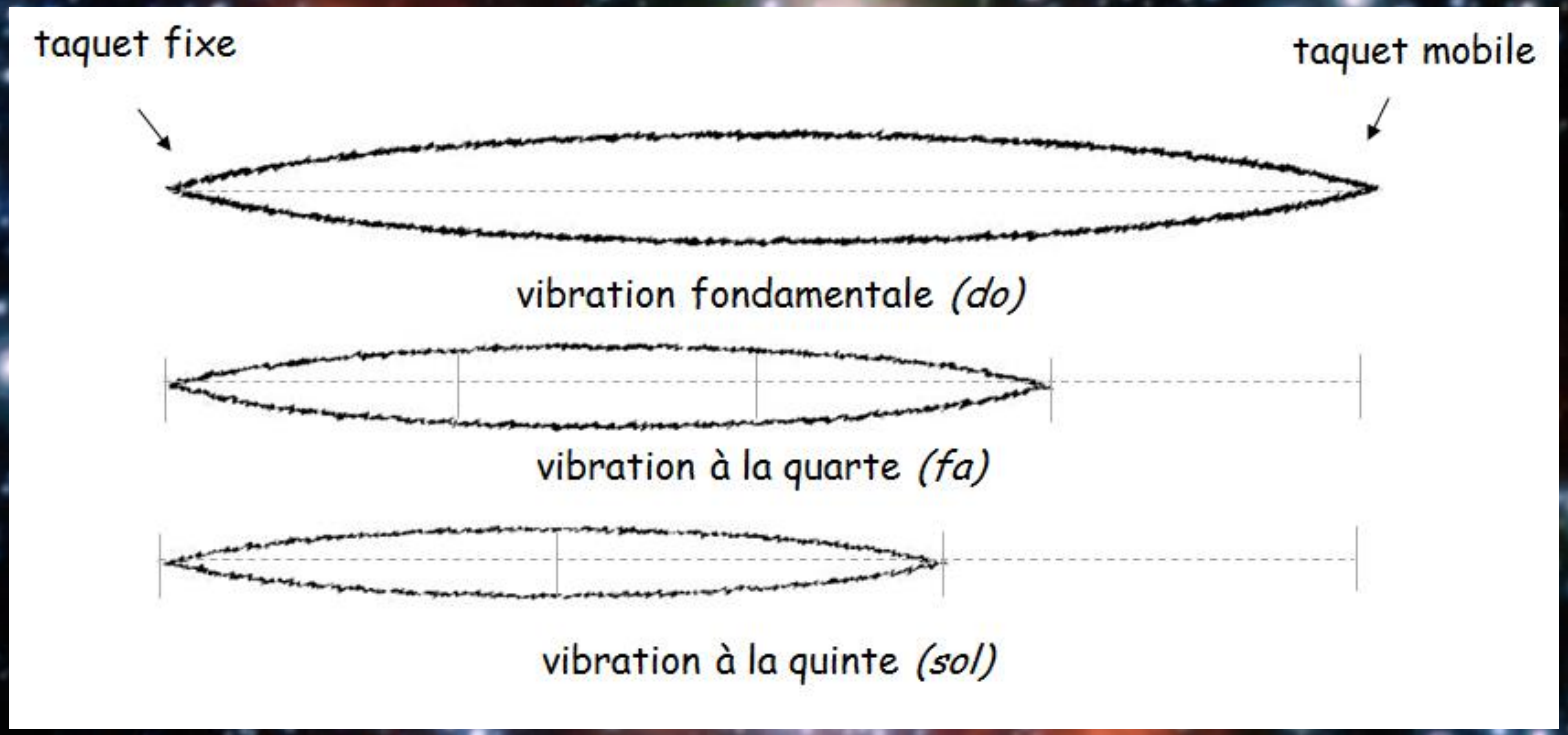
Platon : 428-348 av J-C

Aristote : 384-322 av J-C

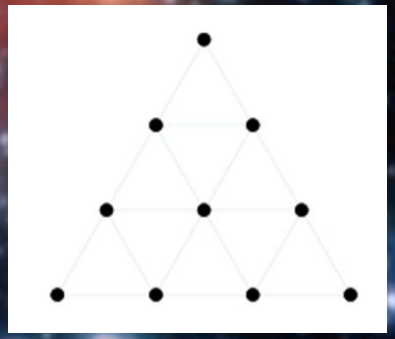
Aristarque : 310-230 av J-C

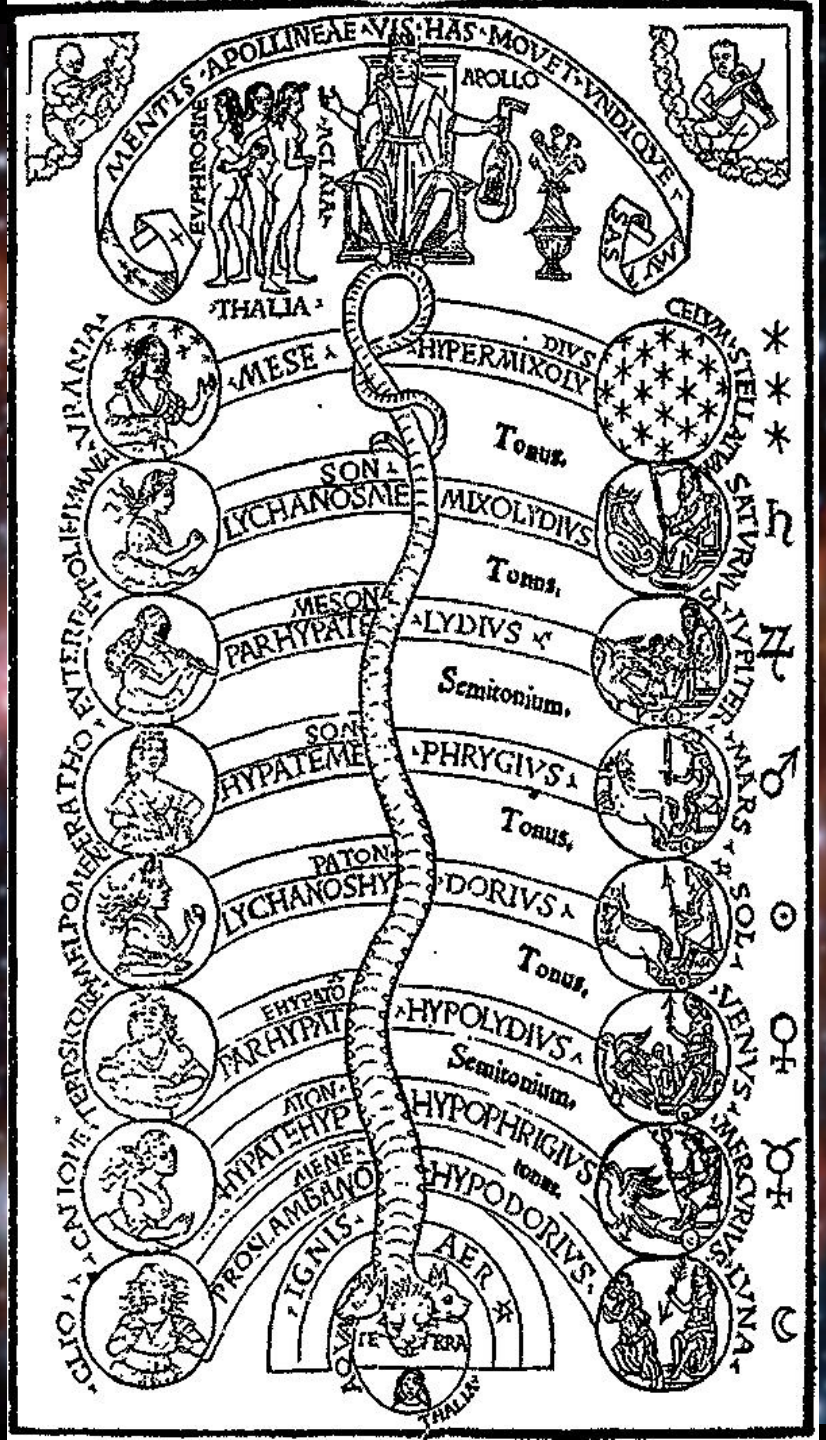

IV BAL
16
12
2
8
PYTACORA
PITAGORAS
PYTACORA
PHYLOLAVS

Intervalles musicaux de Pythagore

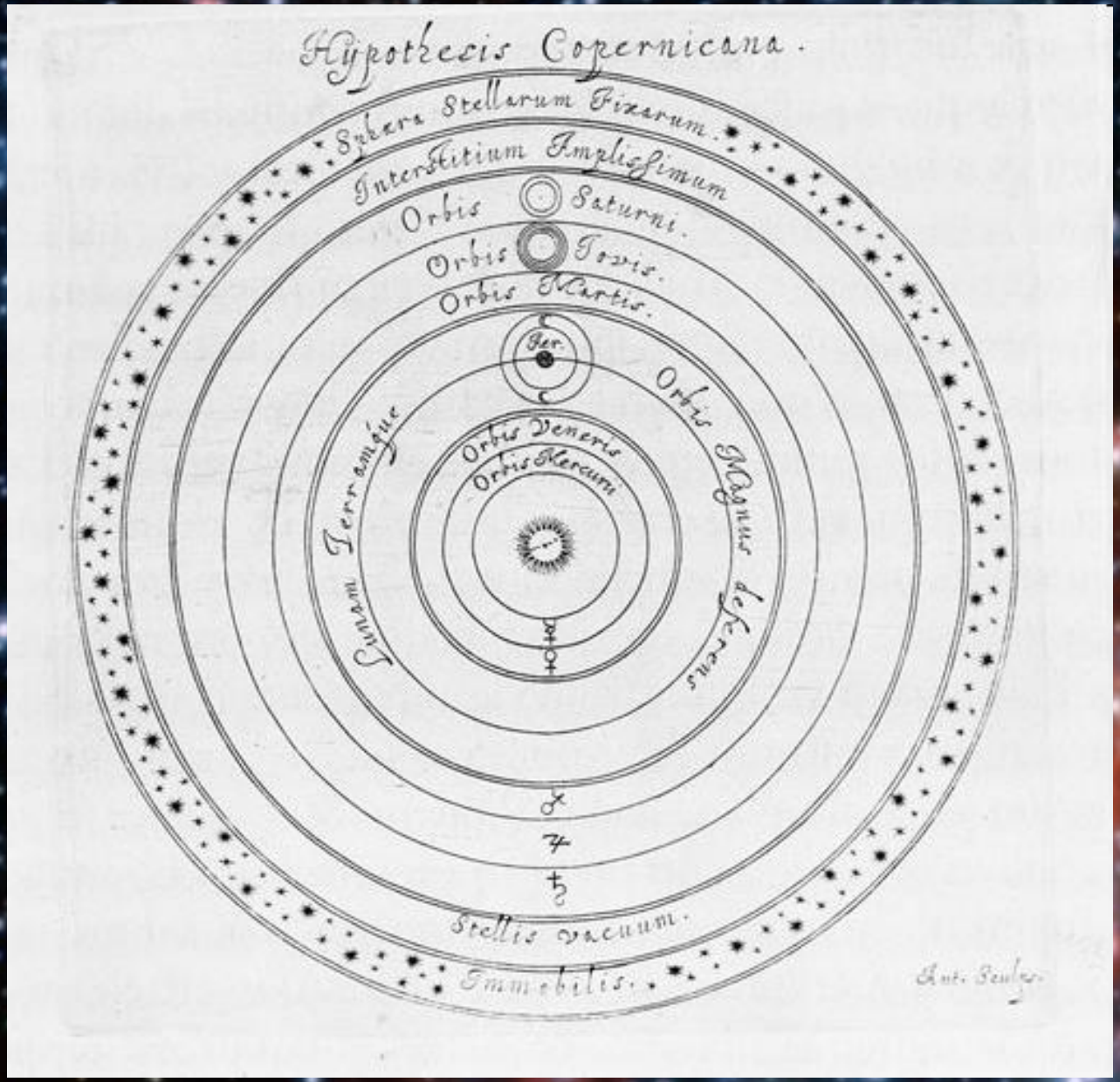


La Tétraktys pythagoricienne





Franchinus Gaffurius
1451-1522



Copernic : 1473 – 1543

Bruno : 1548 - 1600

Galilée : 1564 - 1642

Kepler : 1571 - 1630

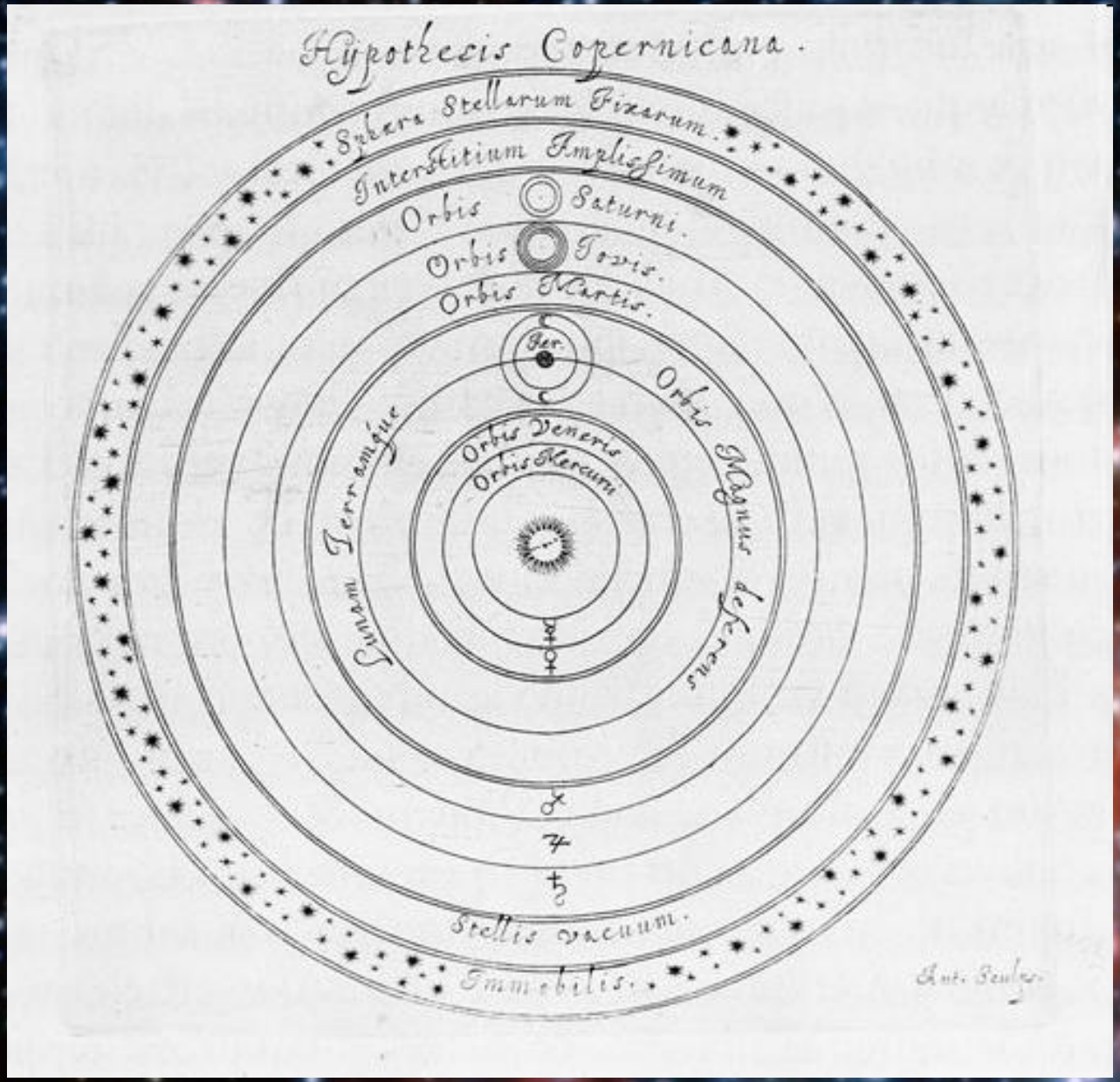
Newton : 1643 - 1727

Pythagore : 560-490 av J-C (?)

Platon : 428-348 av J-C

Aristote : 384-322 av J-C

Aristarque : 310-230 av J-C



Copernic : 1473 – 1543

Bruno : 1548 - 1600

Galilée : 1564 - 1642

Kepler : 1571 - 1630

Newton : 1643 - 1727

Né en janvier 1548, brûlé vif pour ses idées
sur le « Campo dei Fiori » de Rome, le 17 février 1600.

9, 10, 11 octobre, Museum de Toulouse

JOURNÉES GIORDANO BRUNO

9, 10, 11 octobre 2014

Muséum de Toulouse

GIORDANO BRUNO (1548-1600)

Sous l'égide de l'Université de Toulouse et du Consulat Général d'Italie

Avec le soutien de l'Institut culturel italien de Marseille

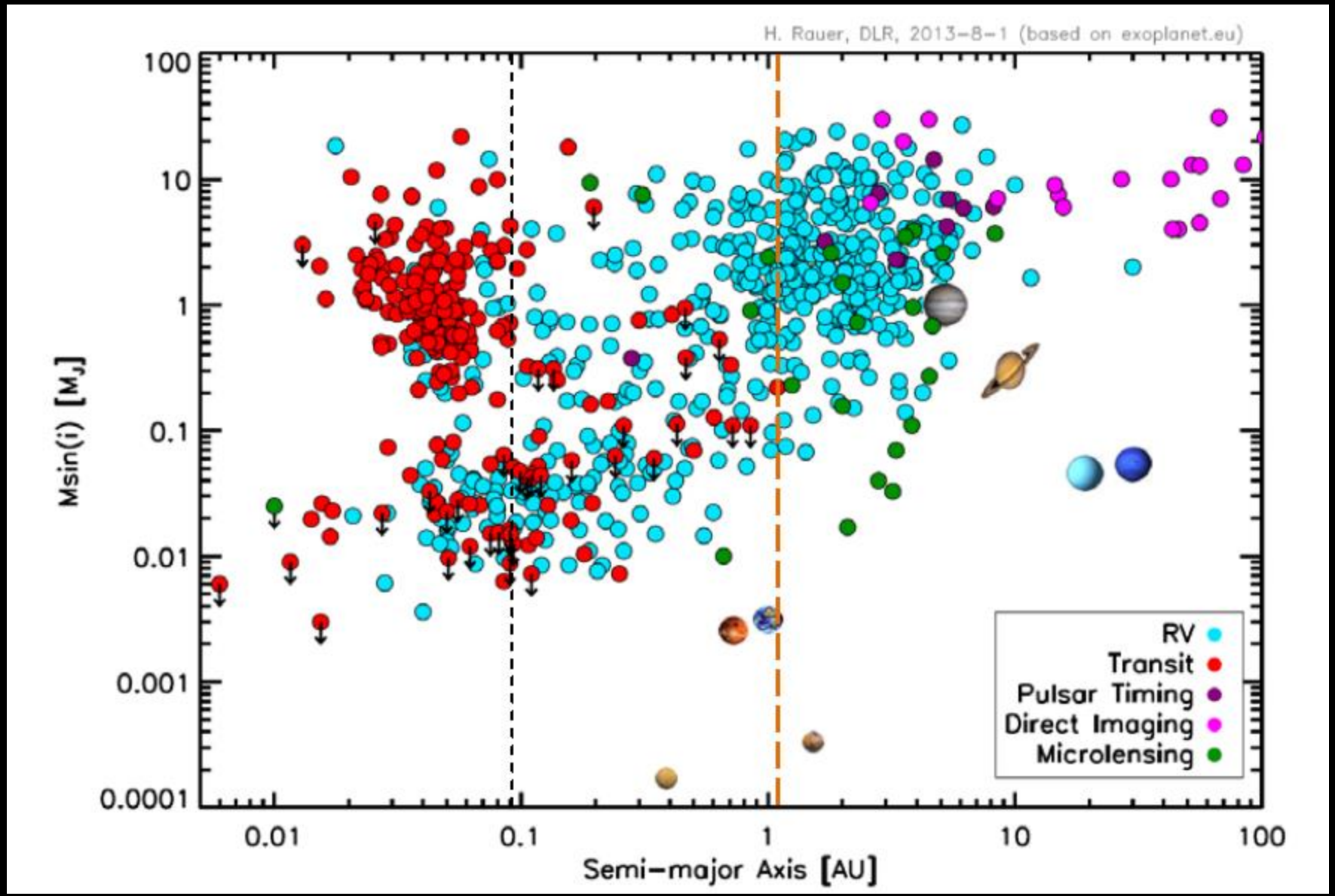
Colloque
« grand public »

Participations de
Philosophes,
Historiens,
Scientifiques …

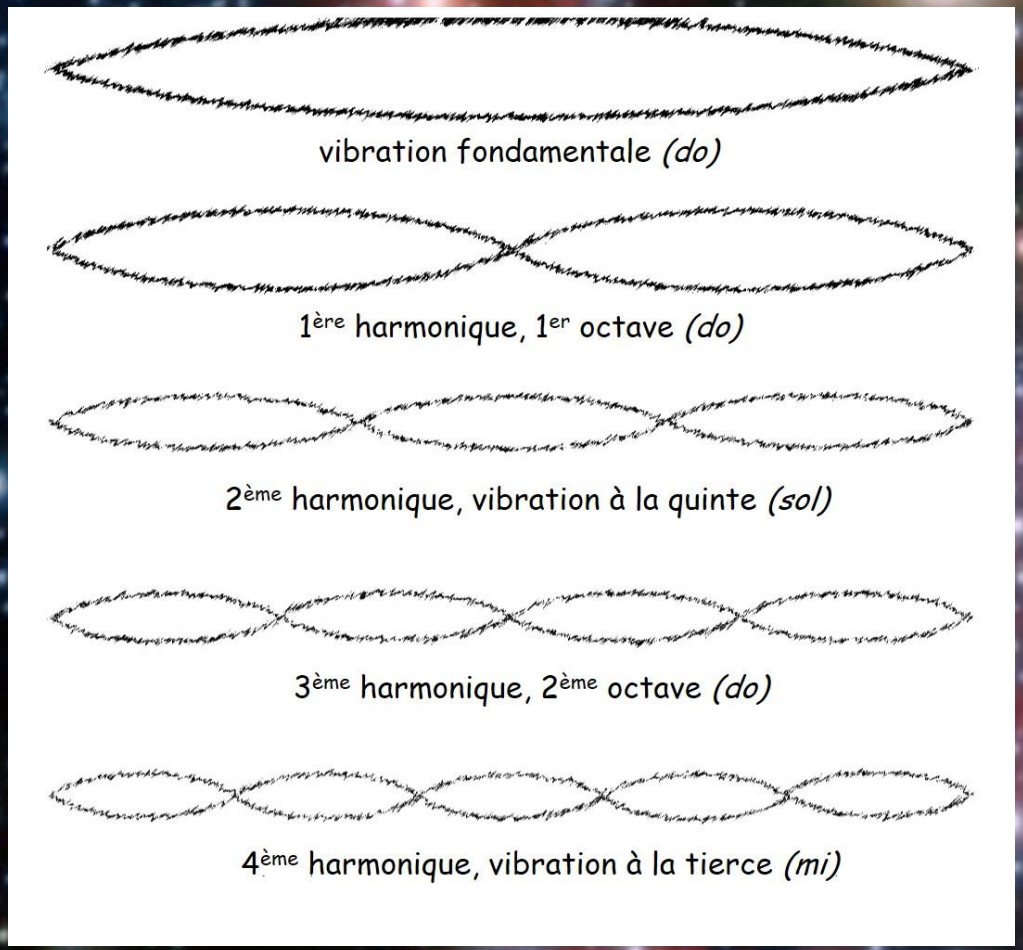
Earth and Moon seen from SATURNE

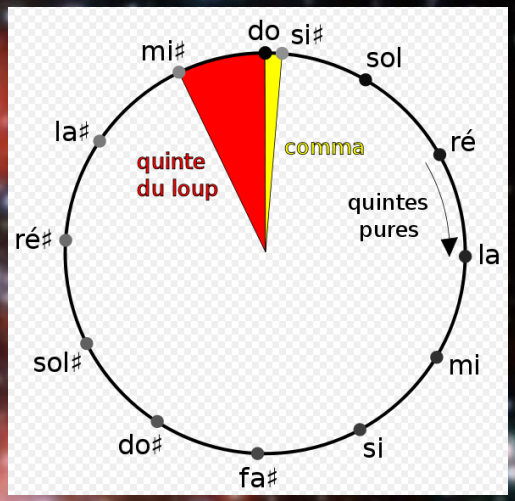
Spacecraft: Sonde spatiale Cassini

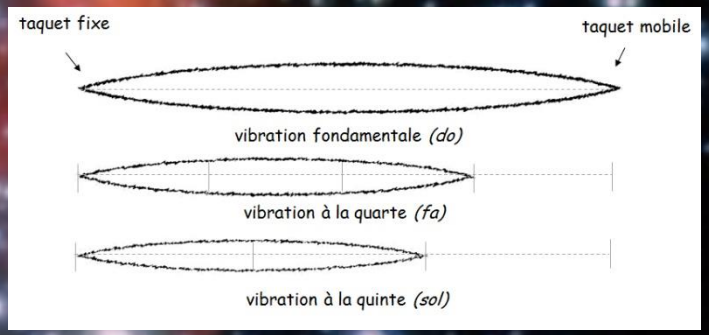
Date taken: Septembre 2006

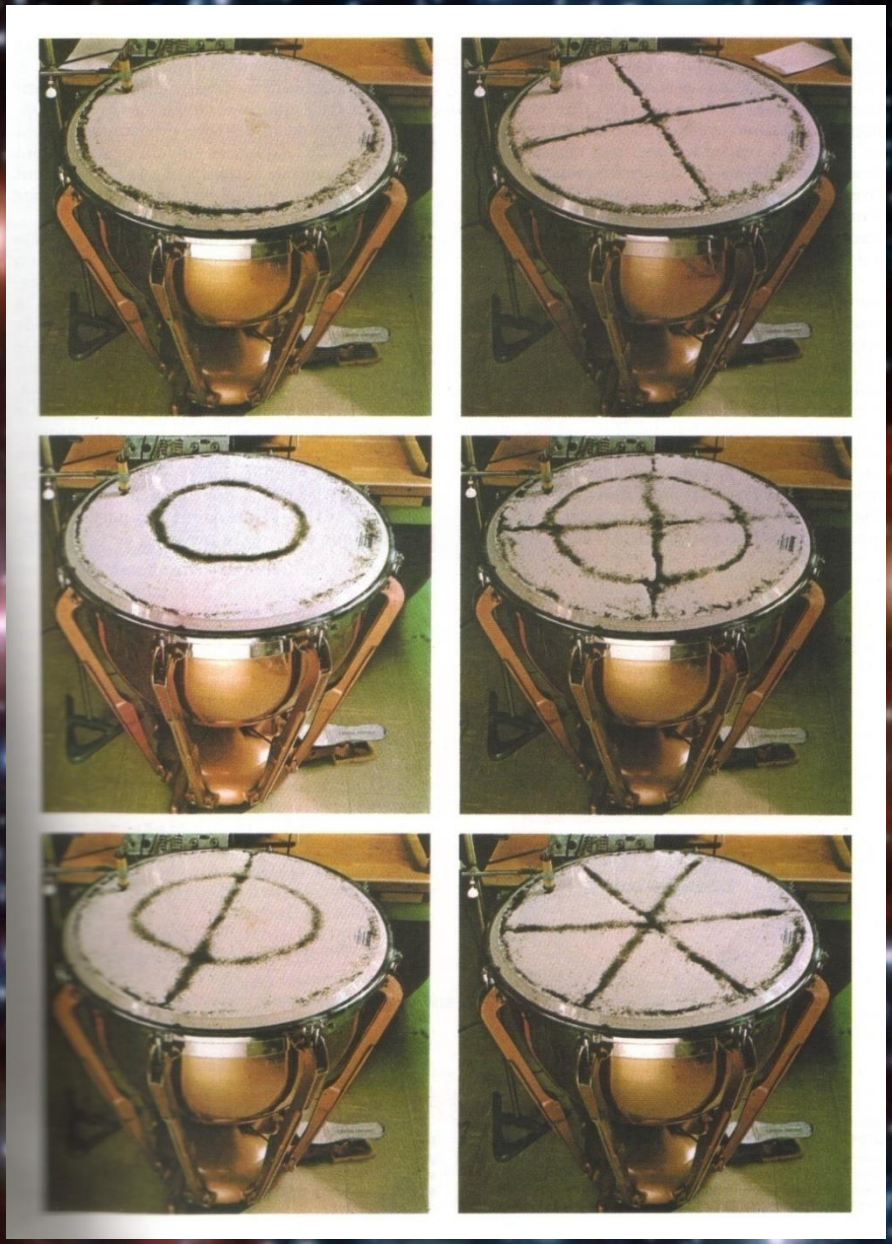

H. Rauer, DLR, 2013-8-1 (based on exoplanet.eu)
Msin(i) [M_J]
Semi-major Axis [AU]
100
10
1
0.1
0.01
0.001
0.0001
0.01
0.1
1
10
100
RV
Transit
Pulsar Timing
Direct Imaging
Microlensing

Les harmoniques d'une corde



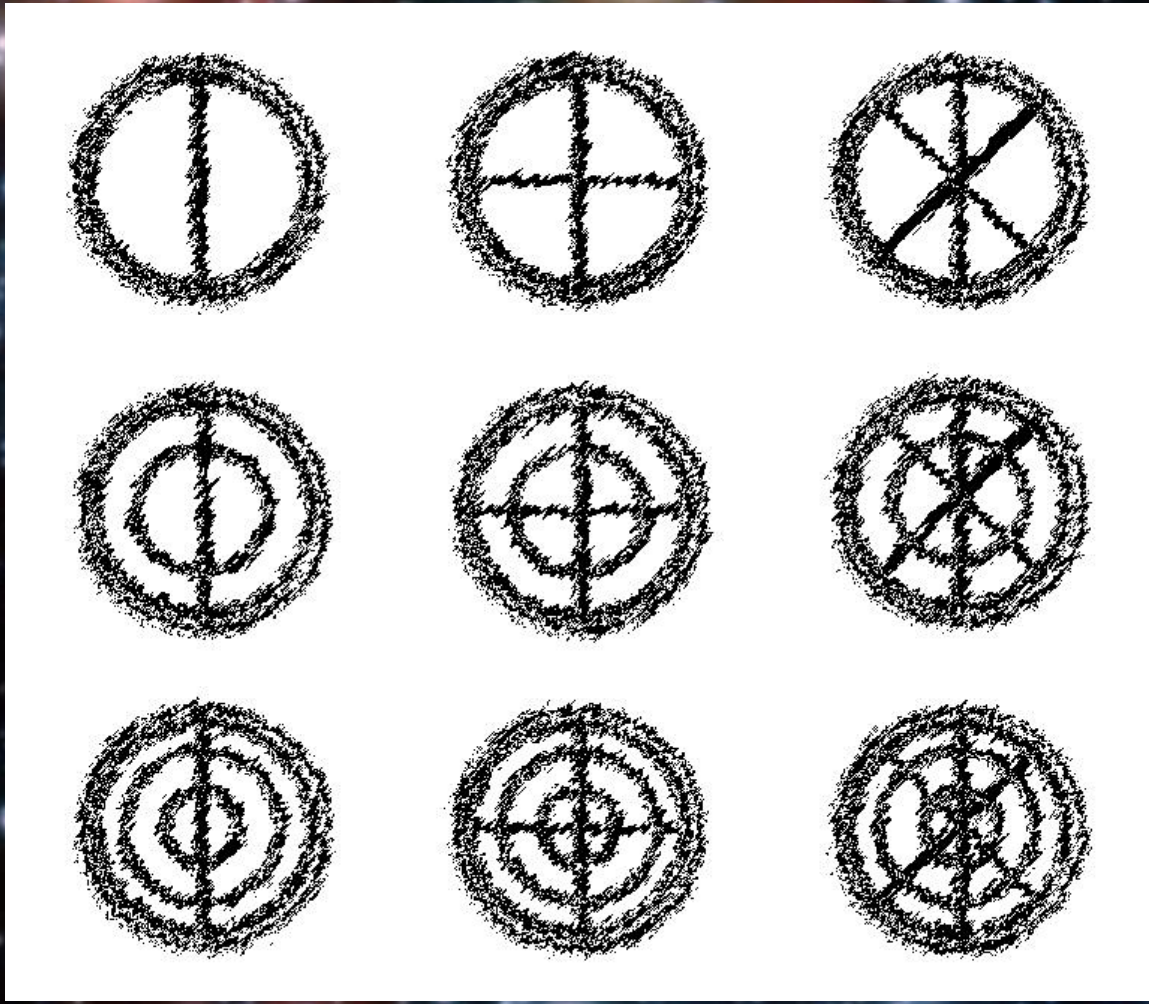




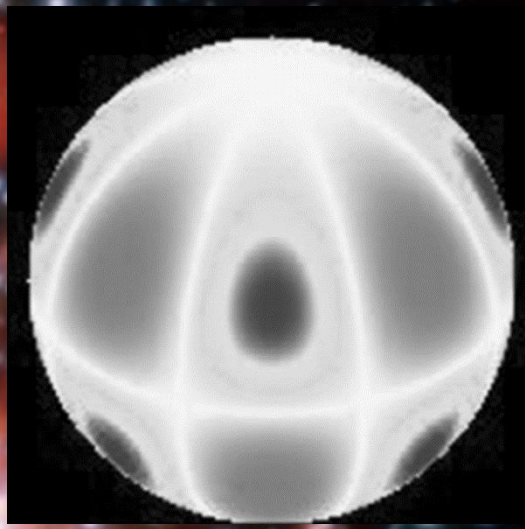


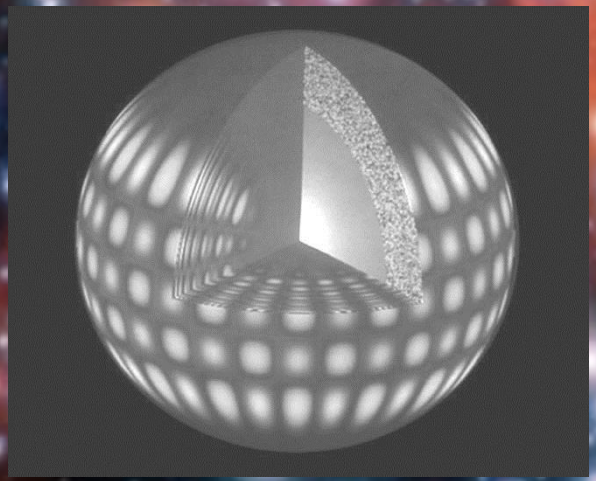
Harmoniques
d'une membrane

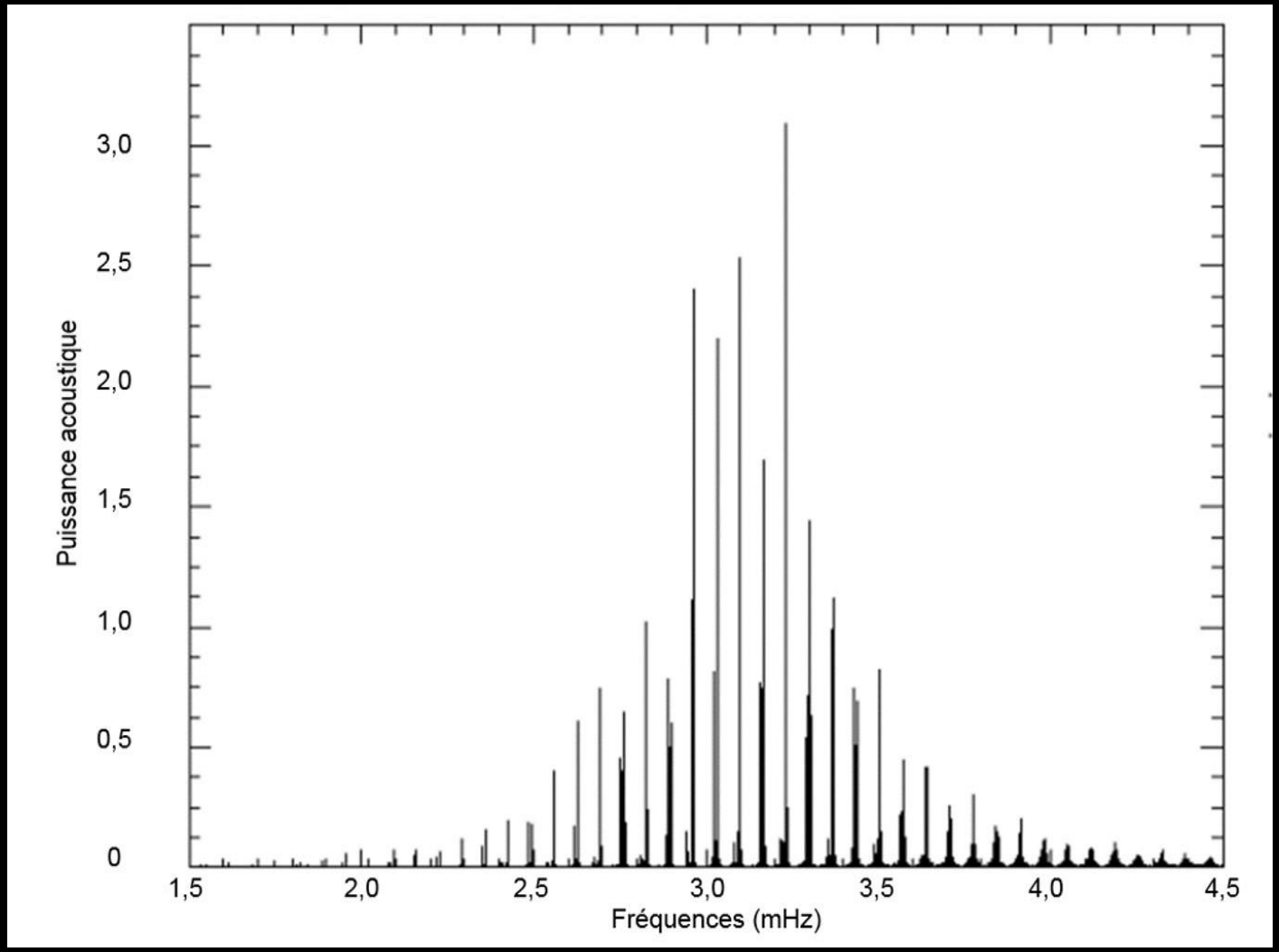
Figures de Chladni



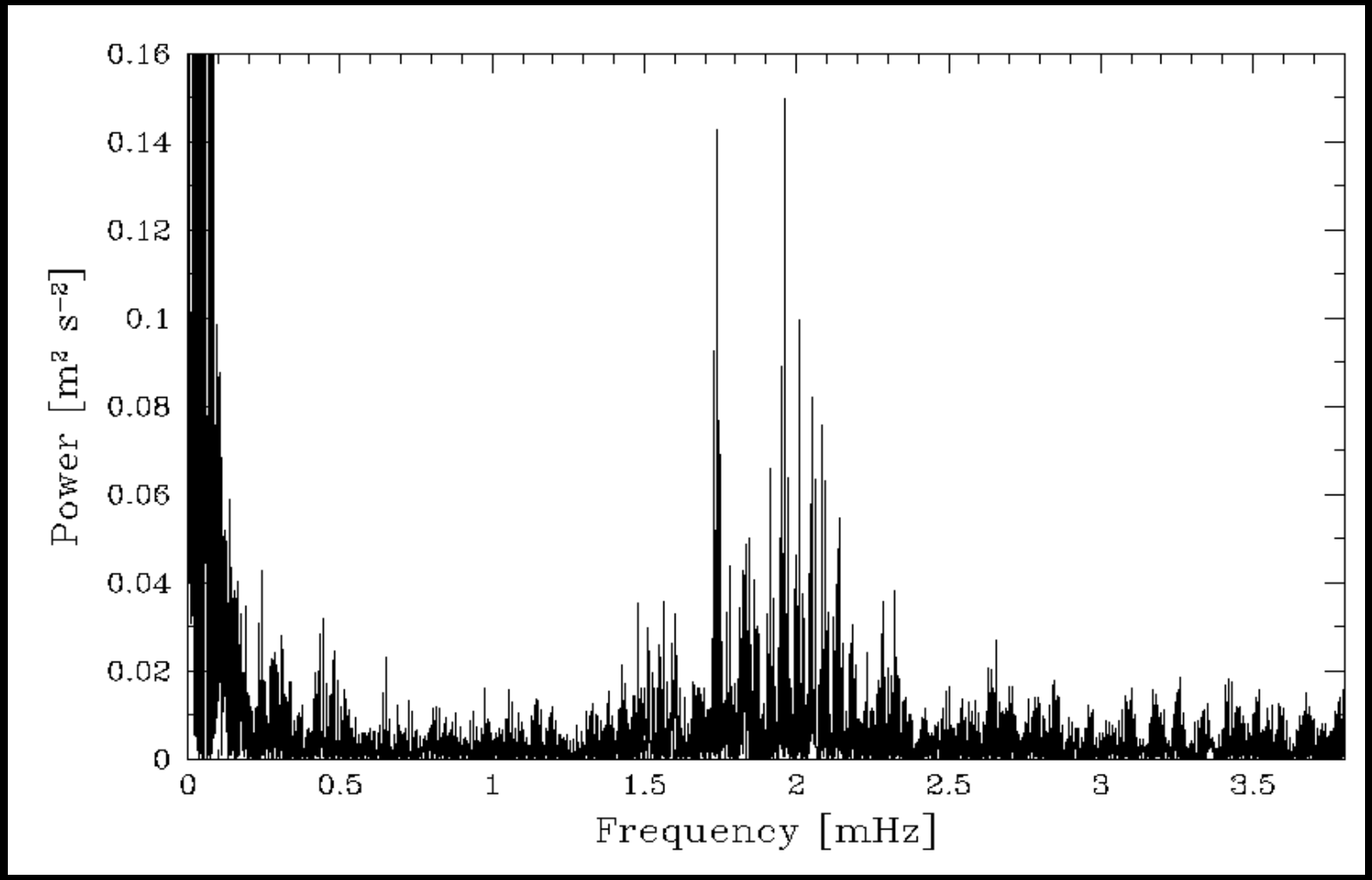
Harmoniques sphériques



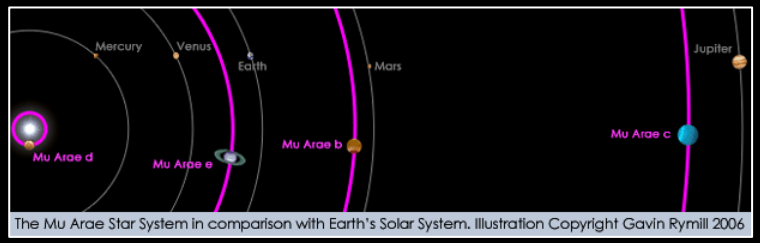


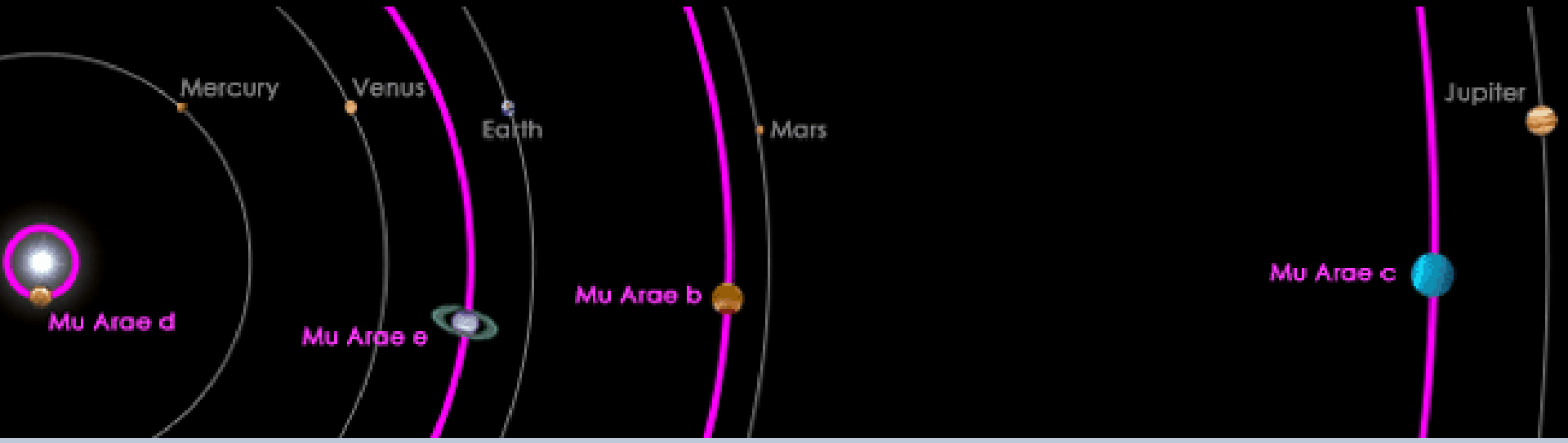


Soleil: spectre acoustique

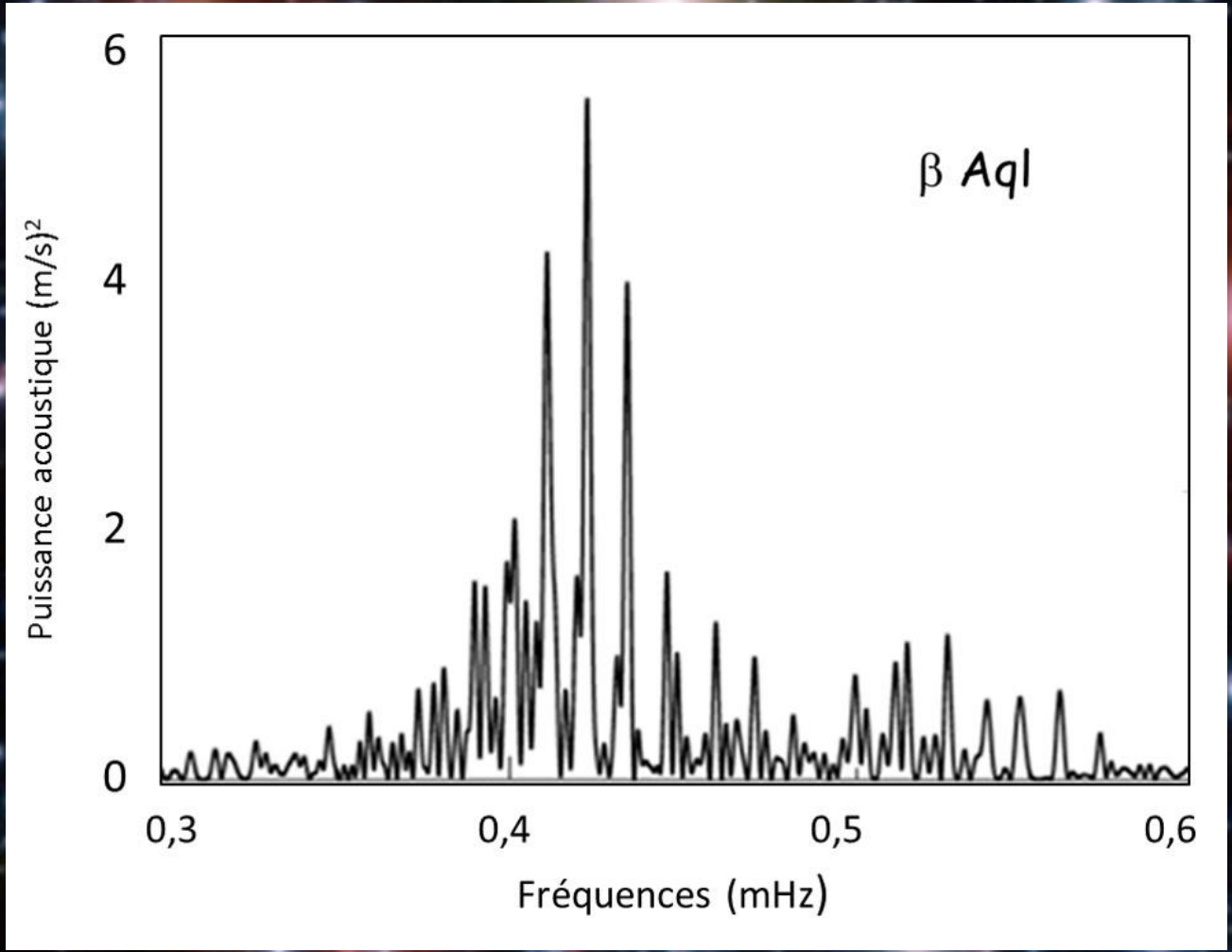


Étoile mu Arae :
spectre acoustique





The Mu Arae Star System in comparison with Earth's Solar System. Illustration Copyright Gavin Rymill 2006


β Aql
Puissance acoustique (m/s)²
6
4
2
0
0,3
0,4
0,5
0,6
Fréquences (mHz)

NOM	CONSTELLATION		DISTANCE	FRÉQUENCE PRINCIPALE		NOTES
de l'étoile	nom latin	nom français	années-lumière	réelle (mHz)	transposée 18 octaves (Hz)	les plus proches
ν Ind	Indus	L'indien	93.6	0,31	81	ré # - **mi**
β Aql	Aquila	L'aigle	44.7	0,42	110	**la**
α CMi A (Procyon)	Canis Minor	Le petit chien	11.5	0,85	223	**la** - si *b*
β Hyi	Hydrus	L'hydre mâle	24.3	1,02	267	**do** - ré *b*
μ Her	Hercules	Hercule	27.1	1,24	325	ré # - **mi**
94 Cet	Cetus	La baleine	73.6	1,35	354	**fa** - sol *b*
μ Ara	Ara	L'autel	50.6	1,96	514	si - **do**
α Cen A	Centaurus	Le centaure	4.3	2,41	632	**ré #** - mi
ι Hor	Horologium	L'horloge	56.0	2,72	713	**fa** – sol *b*
Soleil			0.0000158	3,20	839	**sol #** - la
α Cen B	Centaurus	Le centaure	4.3	4,09	1072	**do** - ré *b*
τ Cet	Cetus	La baleine	11.9	4,48	1174	**ré**

Place à la musique!