VIGIWIND: un projet de météo de l'espace utilisant les voiles solaires

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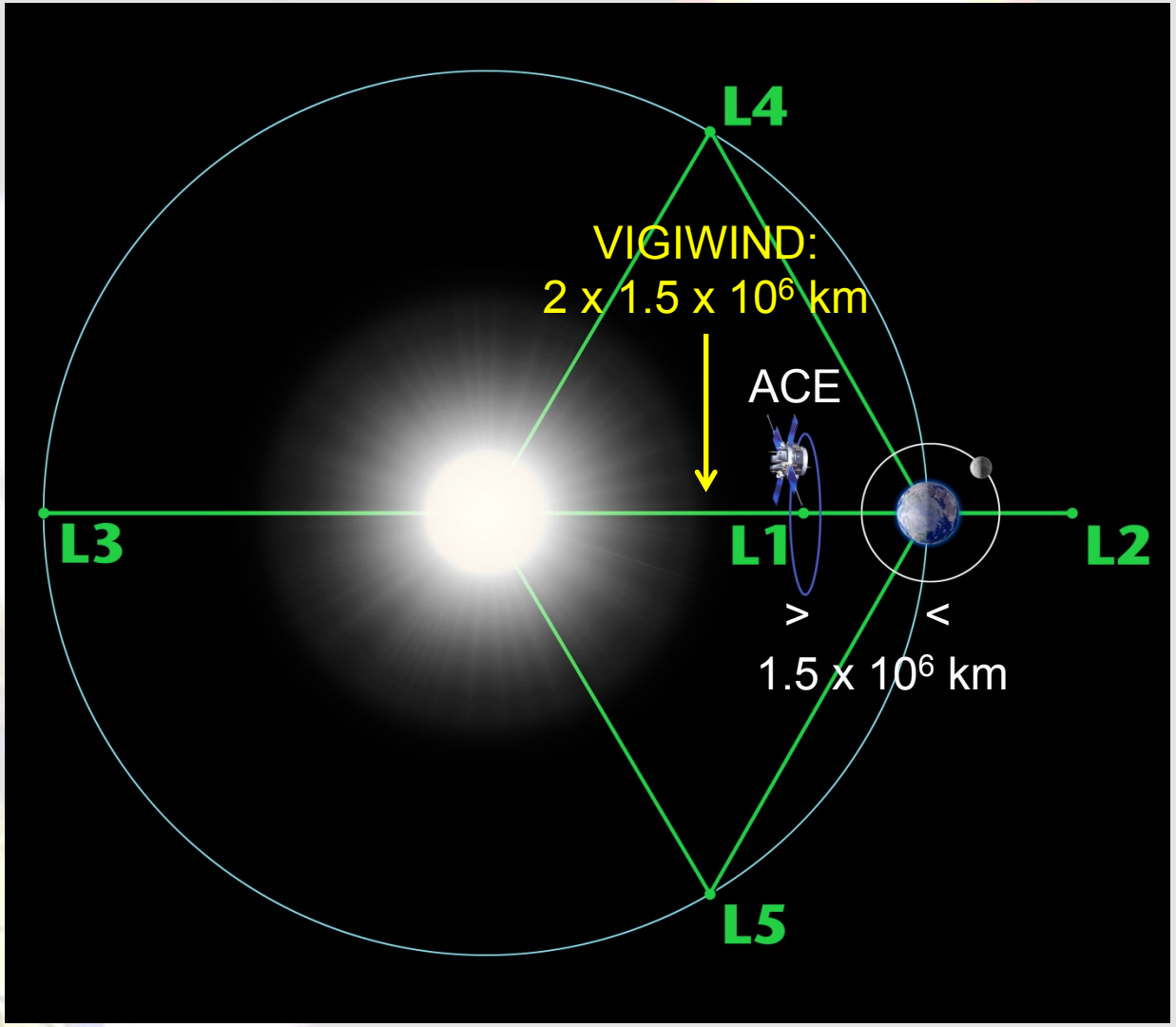


$$\varepsilon = VB^2 \sin^4(\theta/2)\, l^2$$

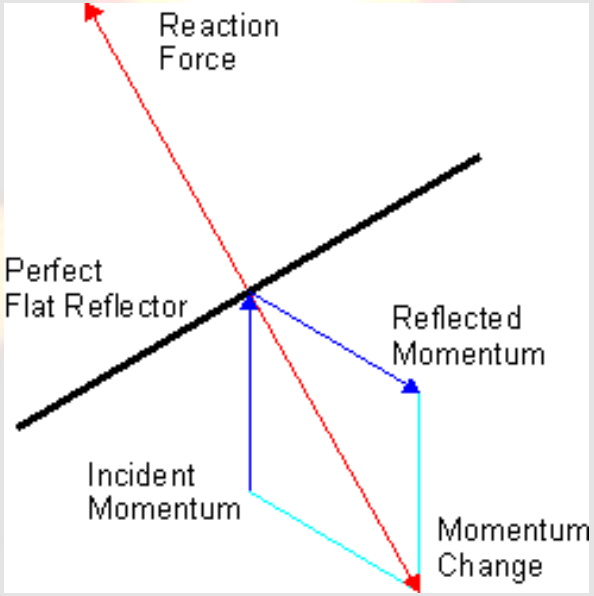
Akasofu, 1981

L1: V_{SW} ~400 km/s -> ~1 hr propagation time

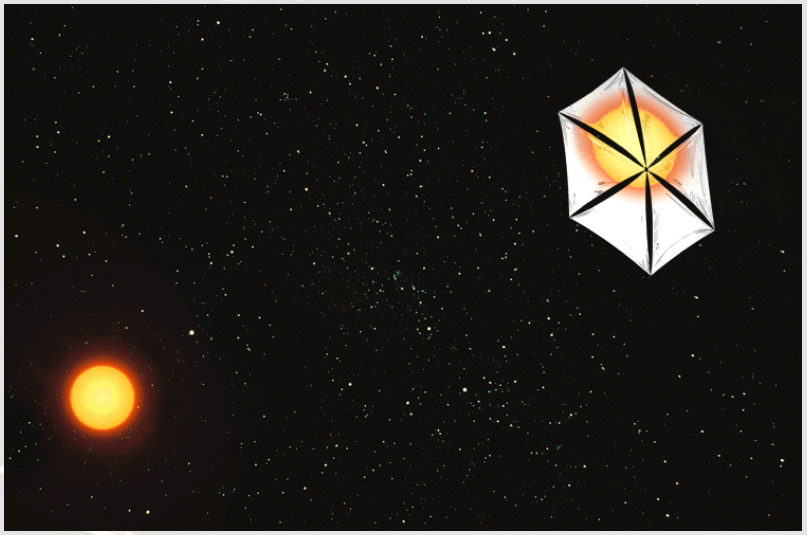
for V_{SW} ~900 km/s (e.g. 21 January 2005 ICME): 28 min. propagation time

VIGIWIND: L'utilisation d'une **voile solaire** permet de se maintenir **plus près du Soleil,** tout en conservant une période de révolution identique à celle de la Terre:

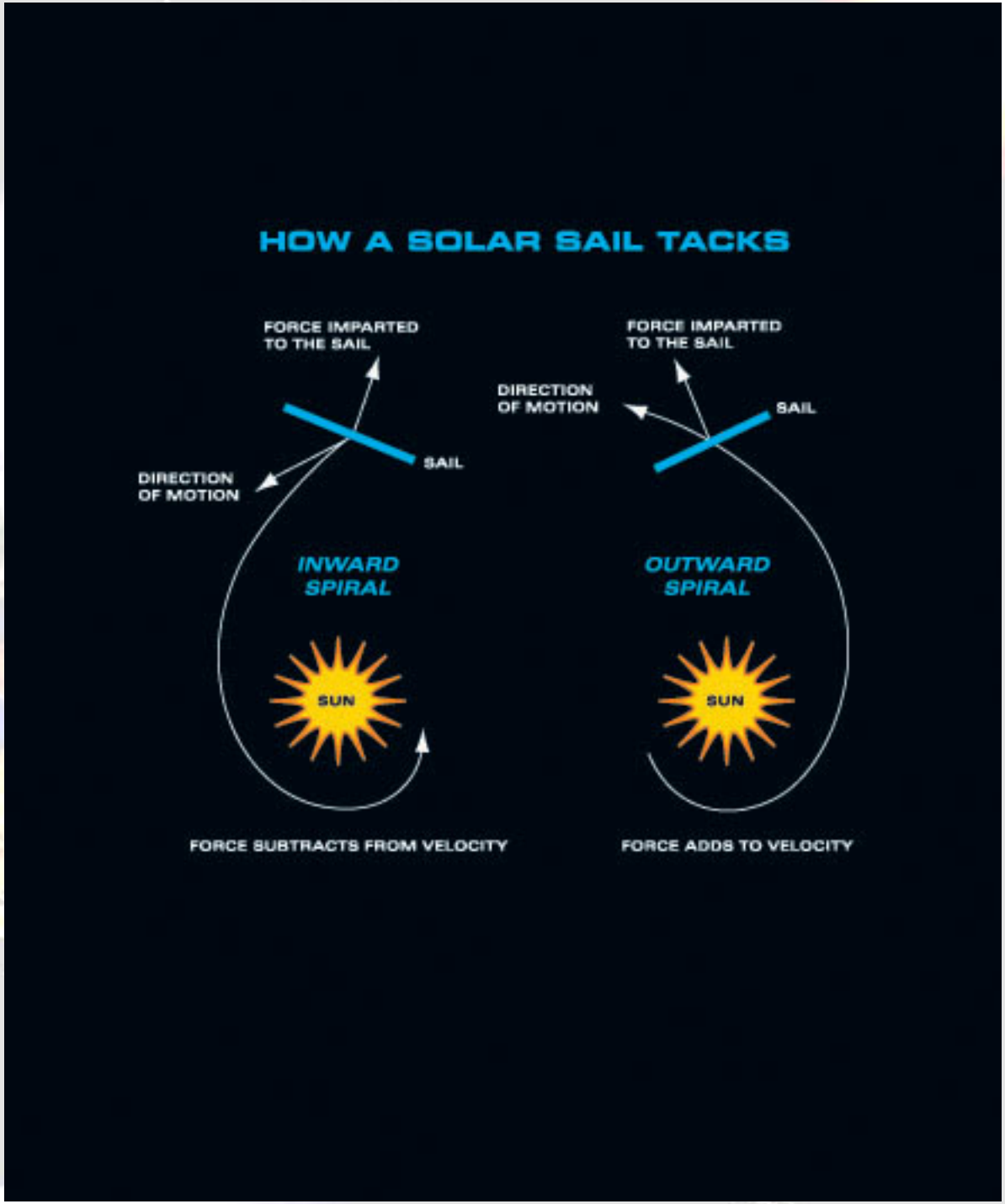
Application de la 3ème loi de Kepler, en réduisant la constante gravitationnelle du Soleil d'un terme, également en $1/R^2$, représentant la **pression photonique**.



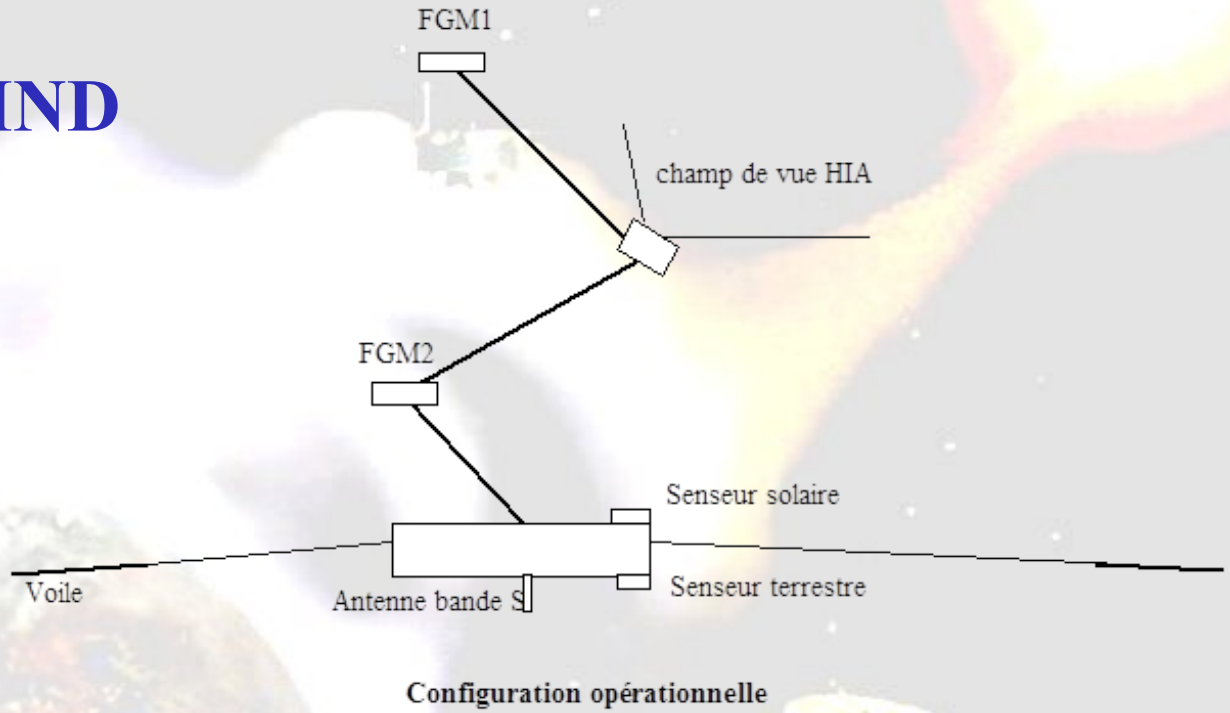
$S / M = 40\ m^2/kg$
par ex. $r = 35$ m pour 100 kg



Dandouras, Pirard, Prado:
High performance solar sails for linear trajectories and heliostationary missions
Adv. Space Res, 2004


HOW A SOLAR SAIL TACKS
FORCE IMPARTED TO THE SAIL
DIRECTION OF MOTION
SAIL
INWARD SPIRAL
SUN
FORCE SUBTRACTS FROM VELOCITY
FORCE IMPARTED TO THE SAIL
DIRECTION OF MOTION
SAIL
OUTWARD SPIRAL
SUN
FORCE ADDS TO VELOCITY

VIGIWIND



Configuration opérationnelle

- First proposal to CNES in '96 (J.L. Bougeret / I. Dandouras)
- mission concept similar to GEOSTORM ~ 100 kg sailcraft@0.98 AU
- ~ 6 kg payload:
  - 3 axis magnetometer (heritage CLUSTER FGM)
  - Hot Ion Analyzer (heritage CLUSTER CIS/HIA)
  - Radio tracking of shocks and electron beams (heritage STEREO S-WAVES)

VIGIWIND (V) / GEOSTORM (G) differences

- VIGIWIND launched by ARIANE5 as a secondary passenger on GTO
  - using two adjacent ASAP plots (*see next slide*)

- G: Kick Off motor for transfer from GTO to heliocentric orbit (C_3~0)

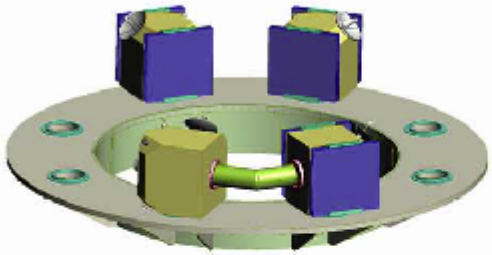
- **V: Solar sail deployment close to Earth**

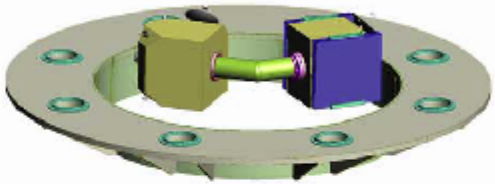
- **V: Navigation with solar sail from Earth to L1**+ and then ~ G

- VIGIWIND/GEOSTORM comparison (advantage V or G)
  - possible use of frequent launch opportunities V
  - solar sail deployment easier to monitor (closer from Earth) V
  - if deployment fails, mission lost G

LAUNCH USING 2 ASAP PLOTS

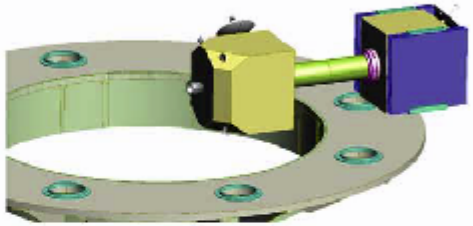
1 - Launch configuration



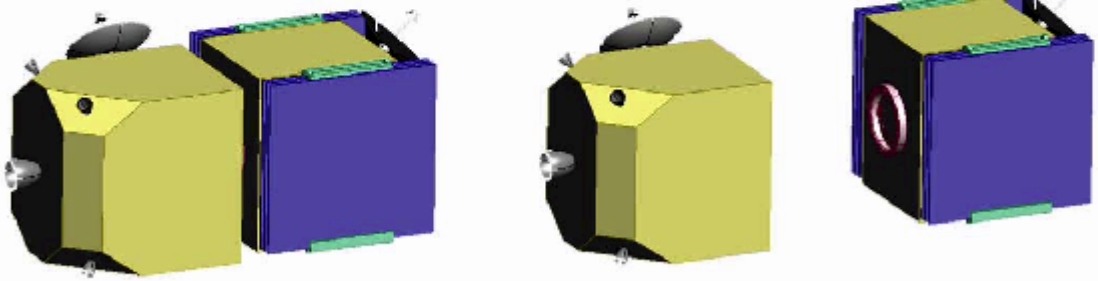


2 - Jettison

3 – Tube retraction

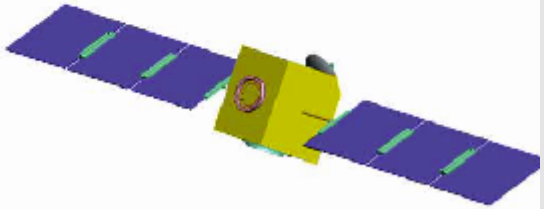


4 – Locking of the modules (orbit transfer)



5 – Separation of the modules

6 - Mission



IDEAMECH

cnes

NB: this example is not related to a sailcraft

Achieving a linear trajectory

- Lightness number > 1 <=> Sail Loading < 1.3 g/m^2

  (Lightness number: ratio of the solar photonic pressure to the gravitational pull)

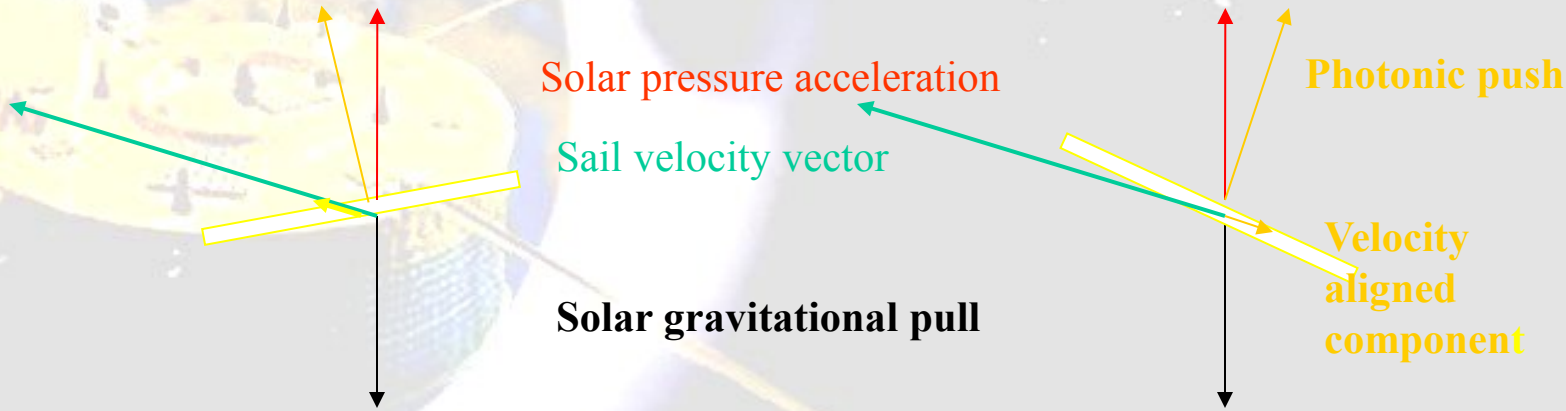
- Performance index constant all over the solar system (both acc. vary with 1/R^2)

- Counterbalance the gravitational pull with the photonic pressure acceleration

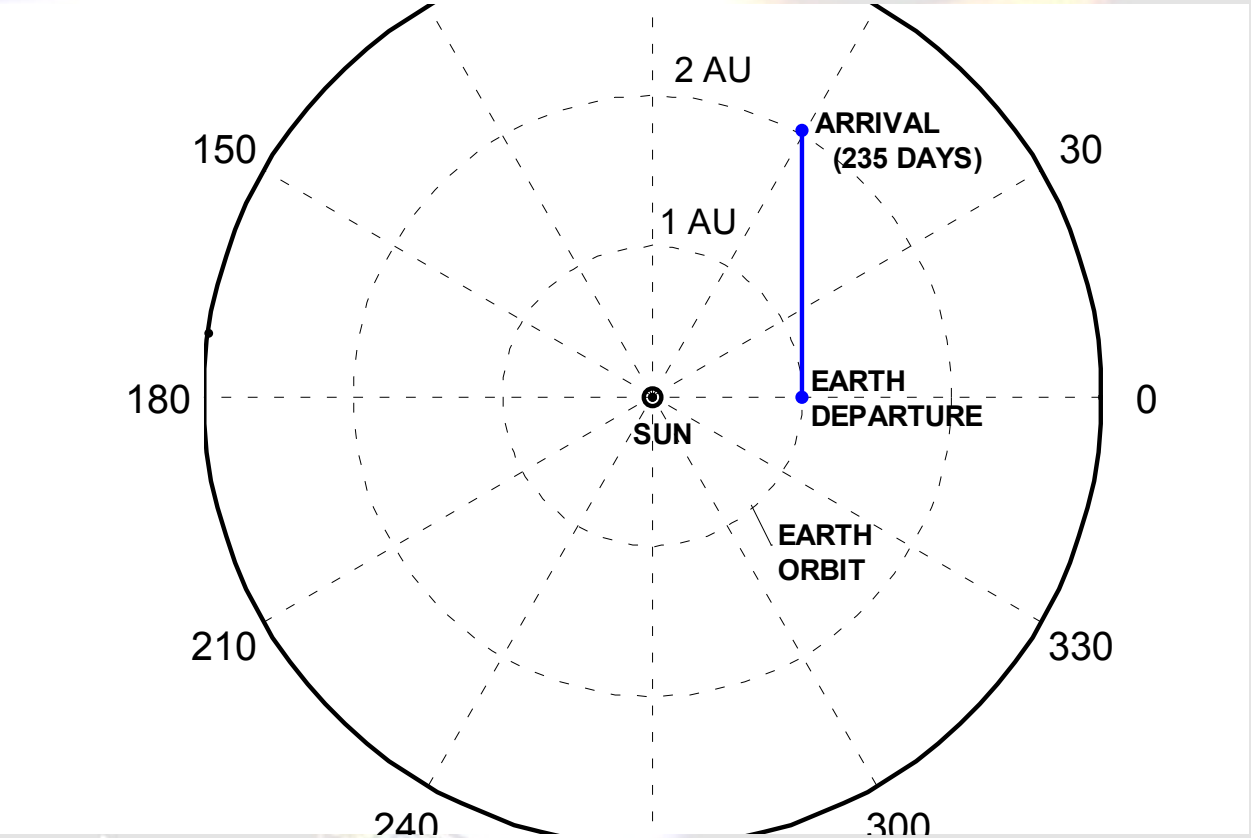
- 2 solutions for the acceleration component colinear to the velocity:

  - increase the velocity

  or decrease it



Stopping in 235 days

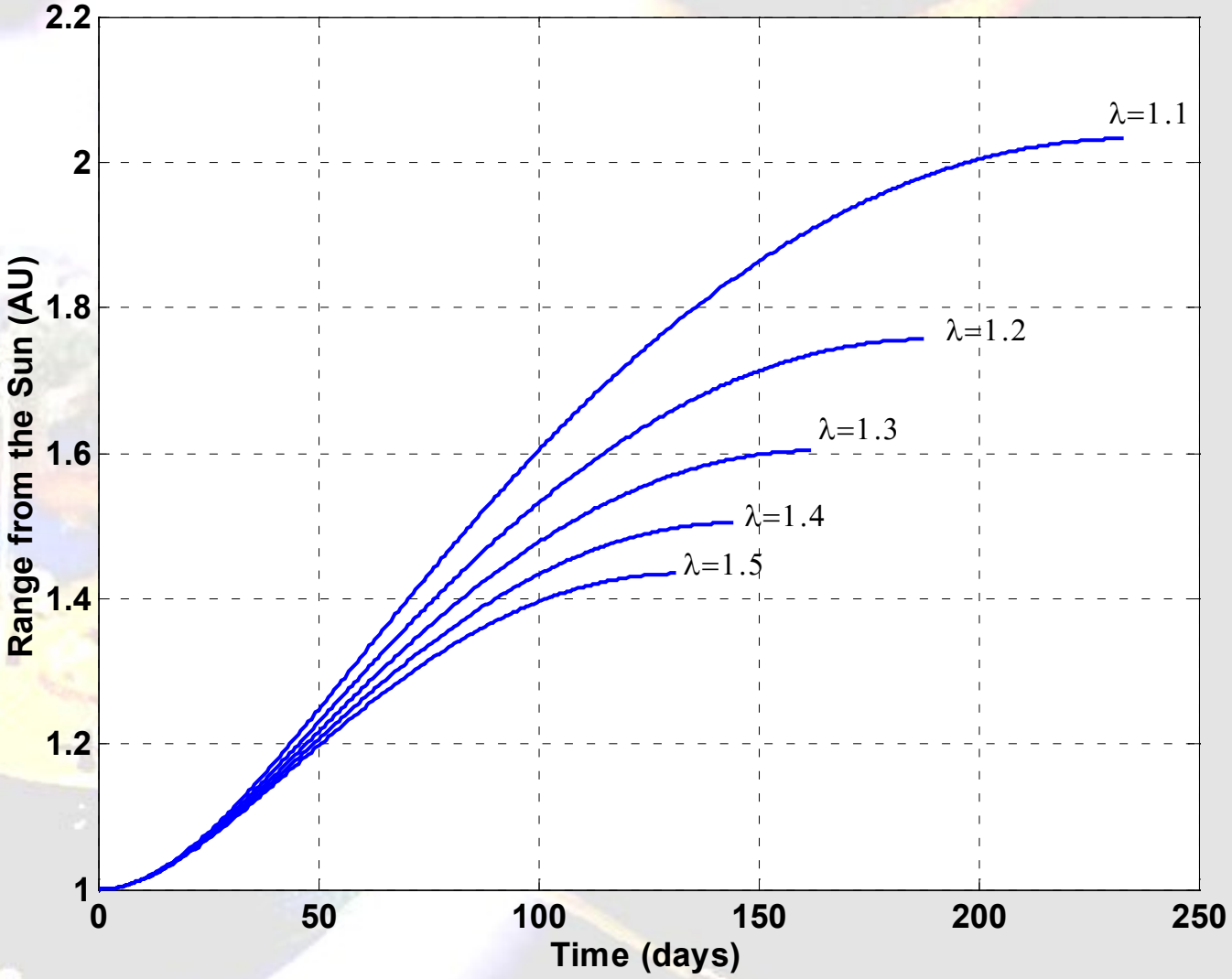


Assumptions

Effective λ=1.1

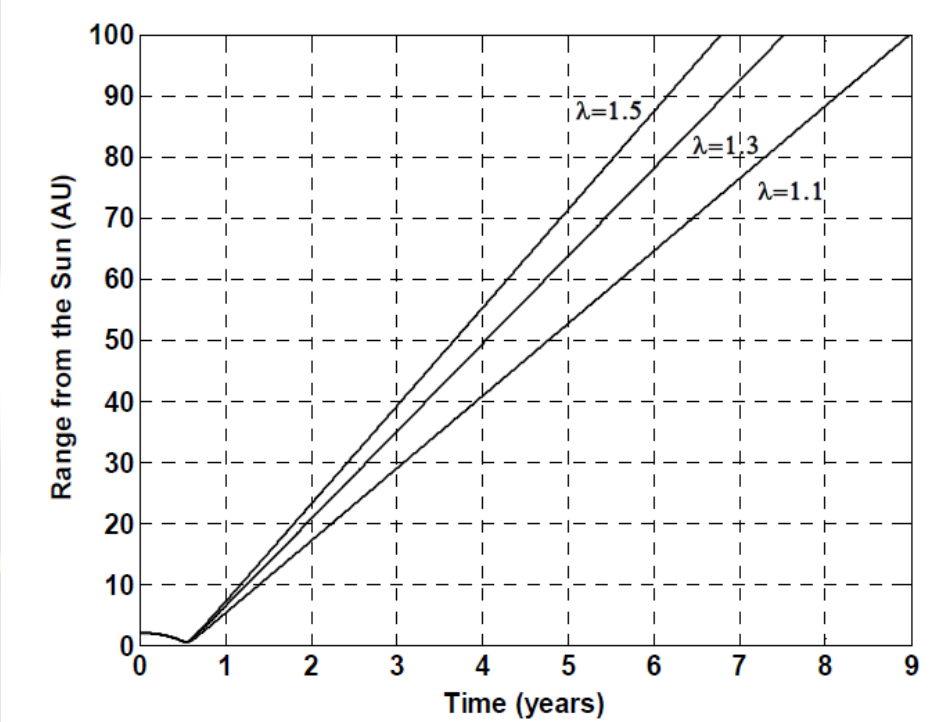
Earth departure C_3=0

Trajectory Sensitivity with Lightness Number



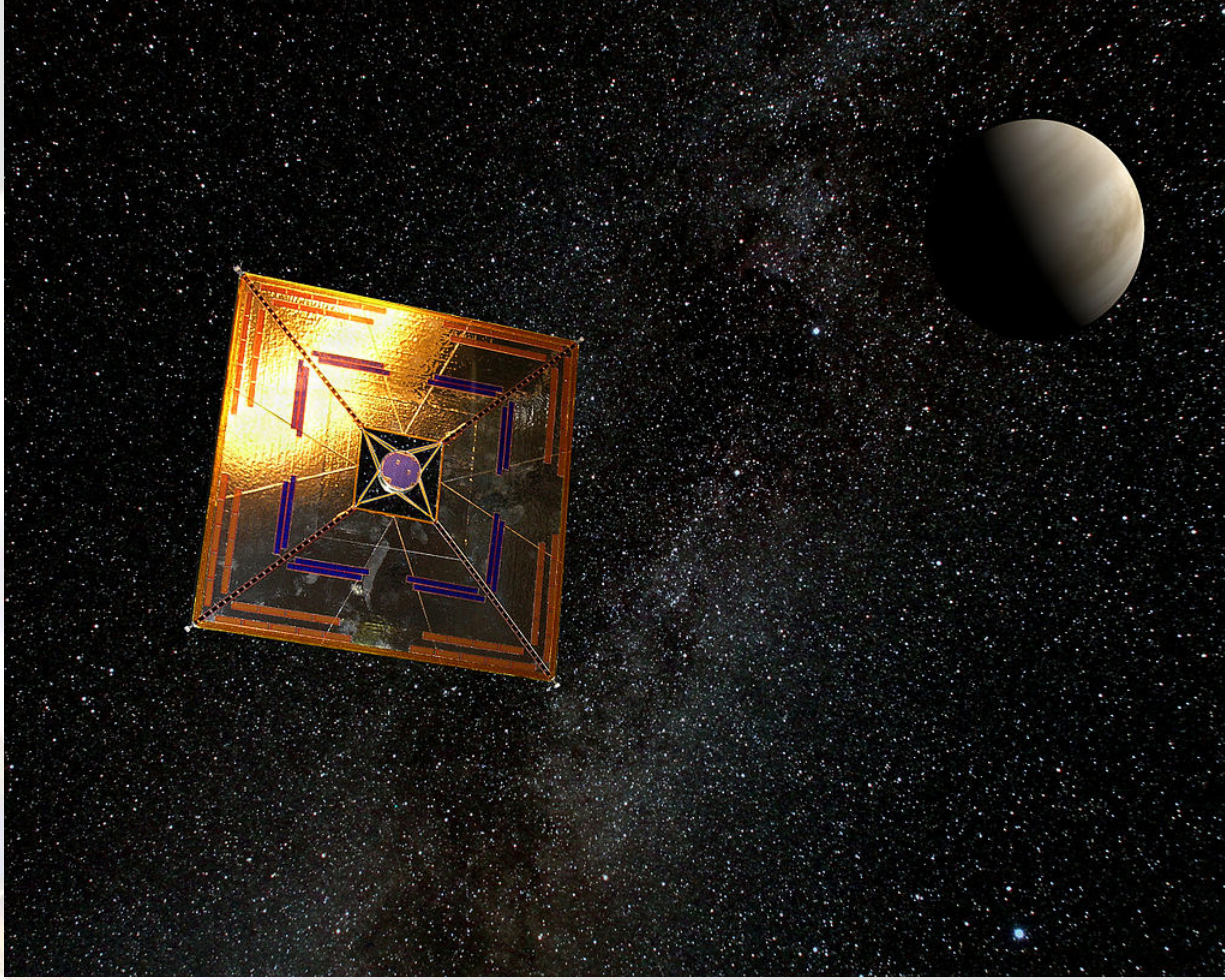
Autres Missions Possibles Utilisant les Voiles Solaires

- Observatoires des Pôles Solaires:
  - satellites stationnaires au dessus des pôles
  - couronne à haute latitude
  - analyse tomographique des CMEs
- Recherche d' Astéroïdes Géocroiseurs
  - satellites stationnaires à l' « intérieur » (<1 AU) de l'orbite terrestre
  - télescope embarqué pointant dans la direction anti-solaire
- Satellites s'échappant du Système Solaire



DLR Solar Sail mock-up

IKAROS



- JAXA
- Lancement: 2010
- Venus Fly-by
- 20 m diagonal sail
- Polyimide sail, 10 g/m^2 :
  propulsion +
  attitude control
- Measured thrust force by the solar rad pressure on the 196 m^2 sail: 1.1 mN

LightSail-A

- Planetary Society
- Triple (3U) CubeSat
- 32 m^2 Mylar sail
- Lancement: Mai 2015

http://sail.planetary.org/