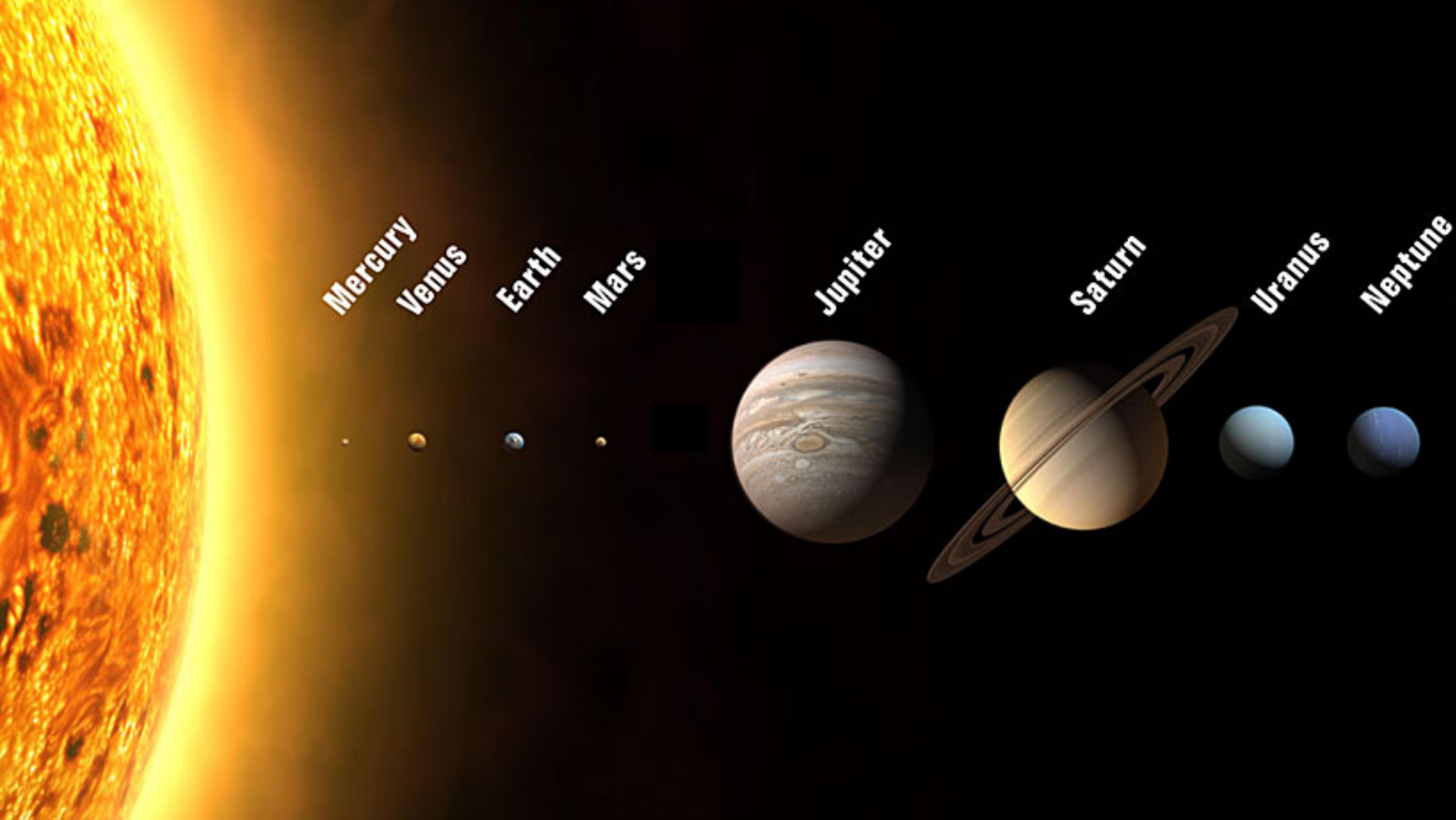


Vers l'infini et au-delà... à la voile

Alesia Herasimenka







Mercury

Venus

Earth

Mars

Jupiter

Saturn

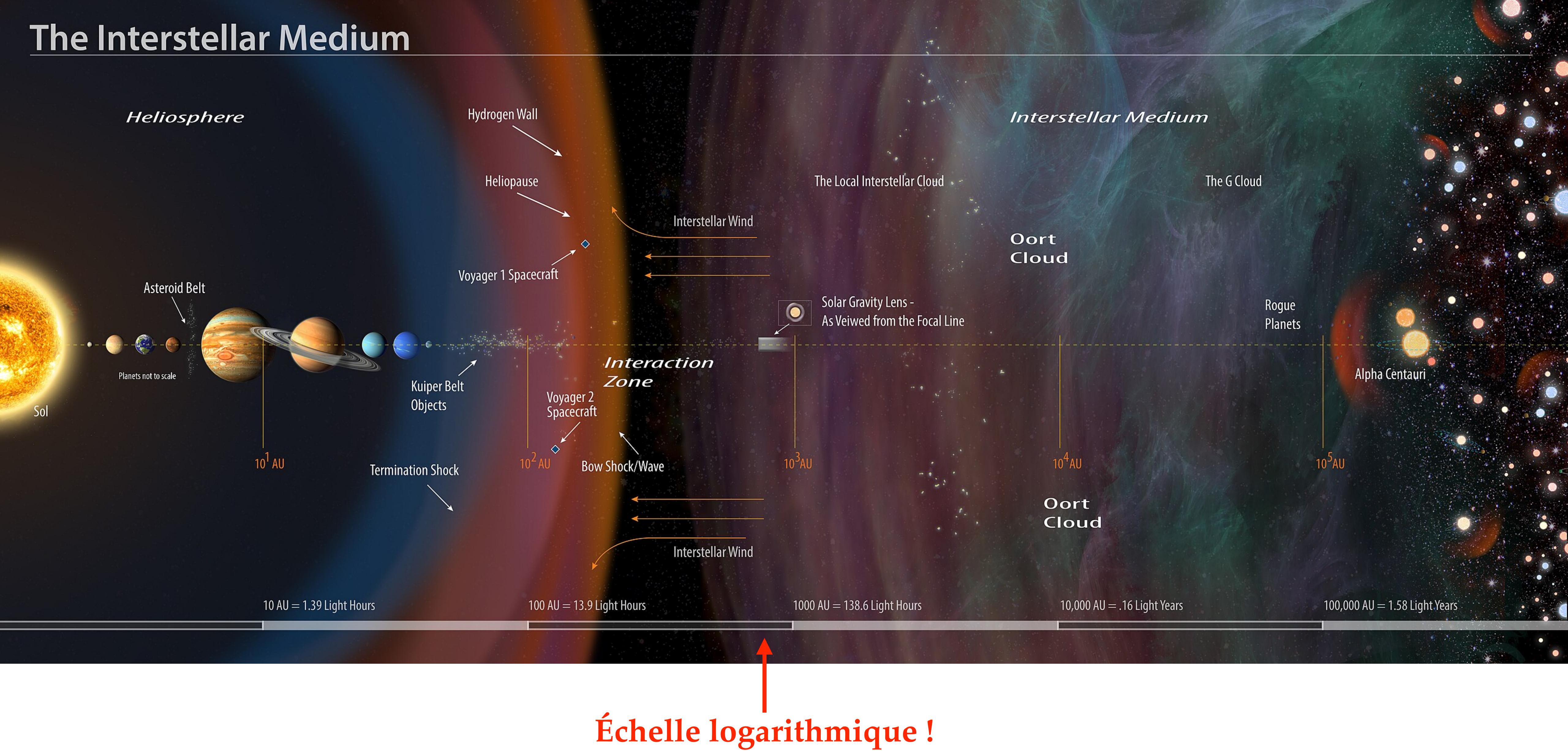
Uranus

Neptune

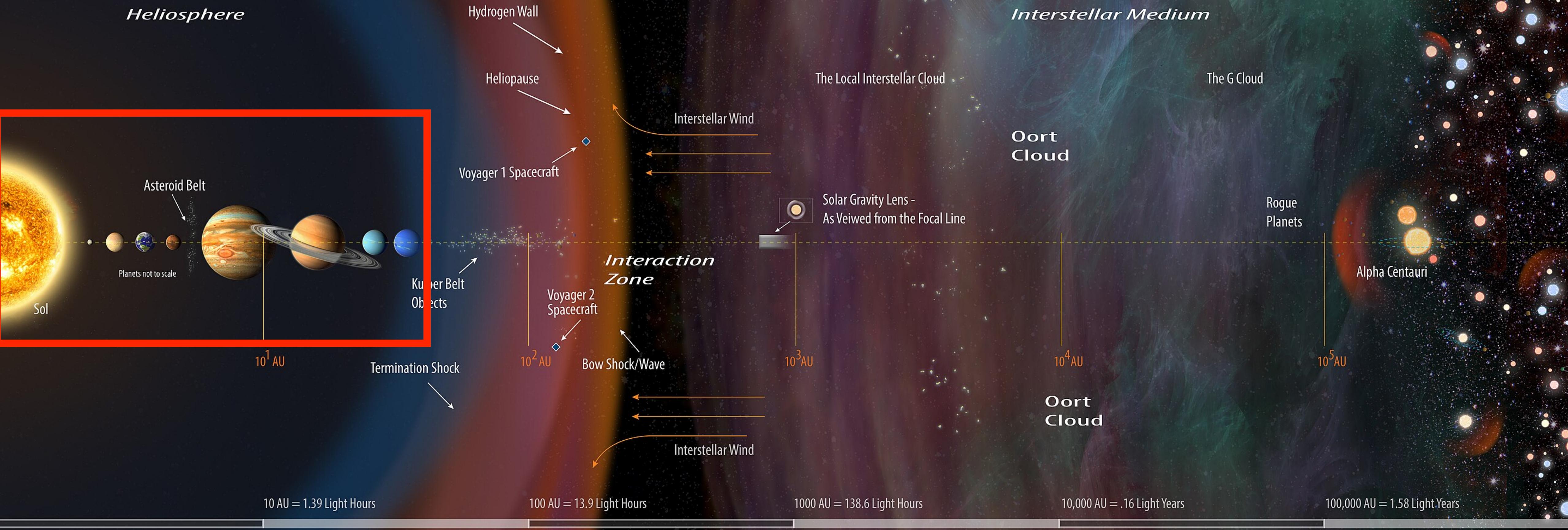


We are here →

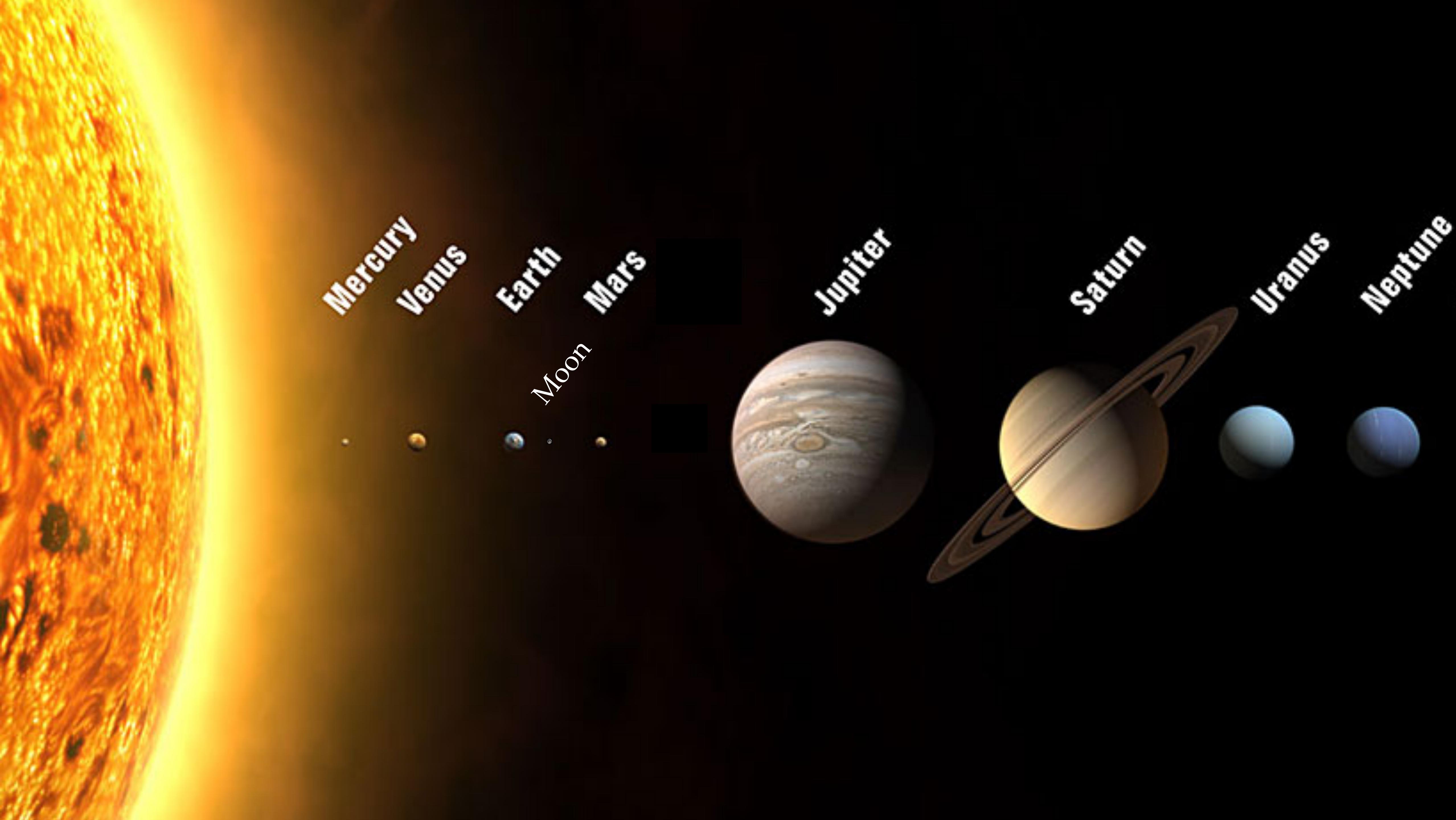
The Interstellar Medium



The Interstellar Medium



Échelle logarithmique !



Mercury

Venus

Earth

Mars

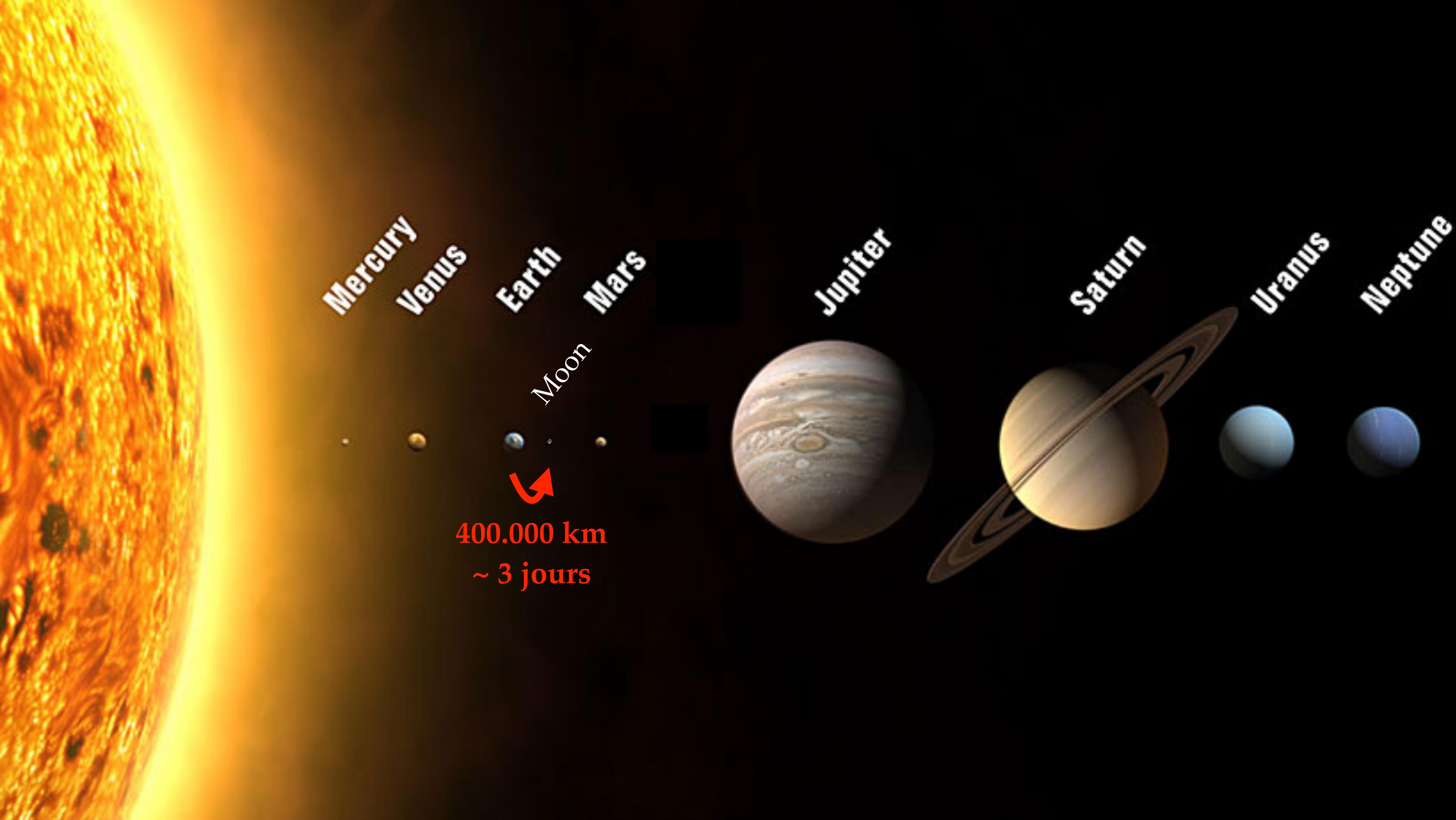
Moon

Jupiter

Saturn

Uranus

Neptune



Mercury
Venus

Earth
Mars

Moon

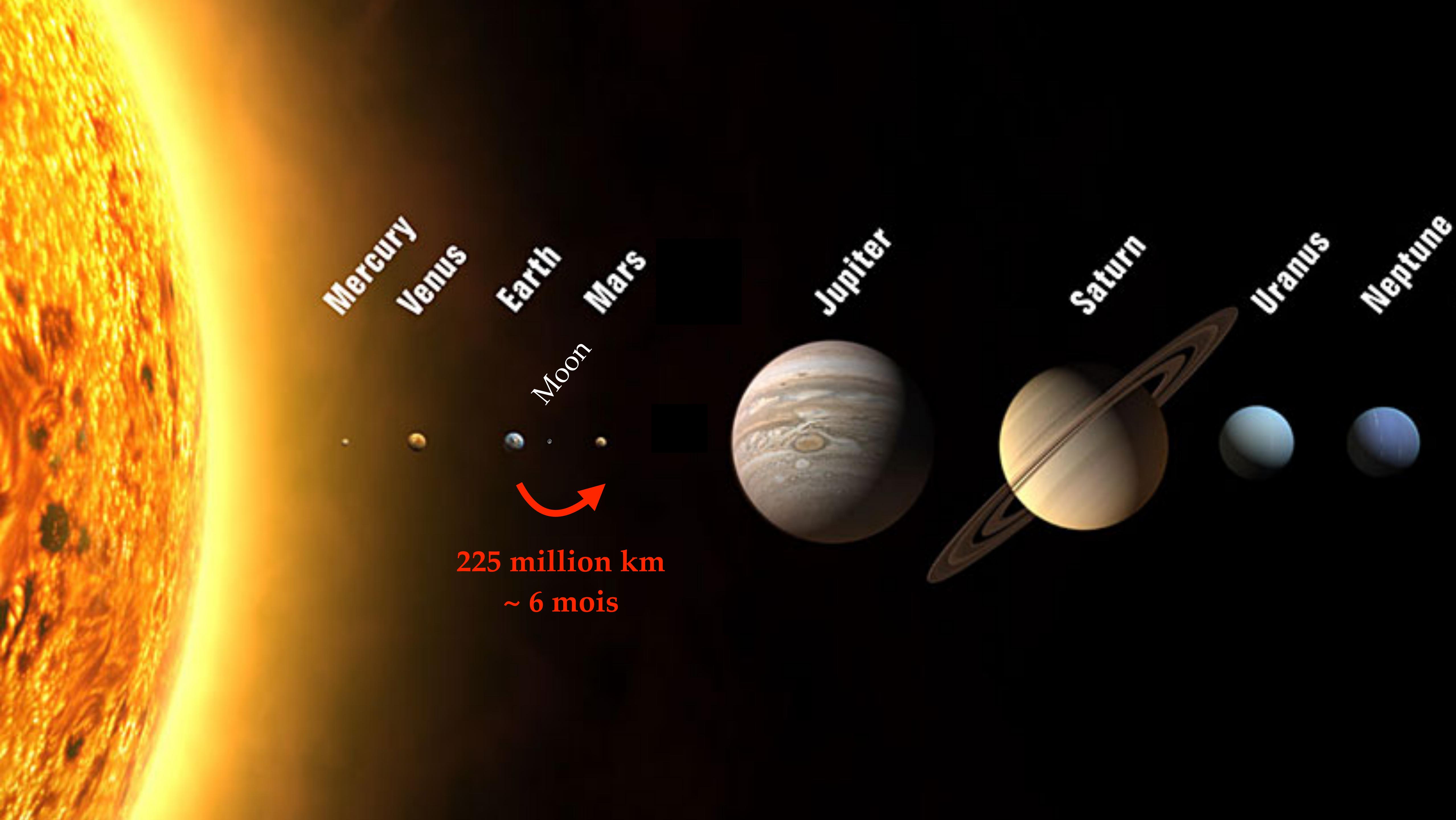
Jupiter

Saturn

Uranus

Neptune

400.000 km
~ 3 jours



Mercury
Venus

Earth
Mars

Moon

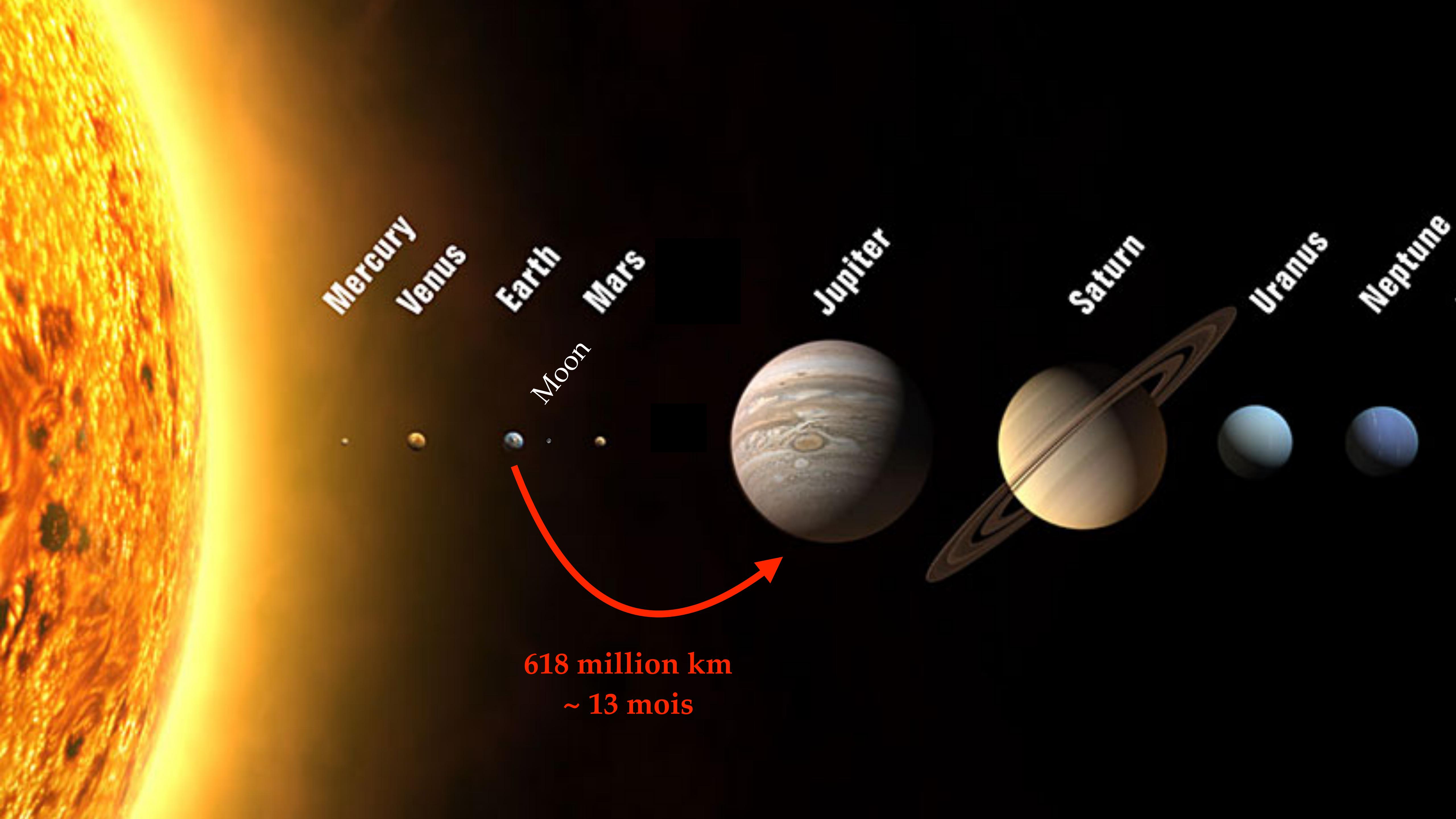
Jupiter

Saturn

Uranus

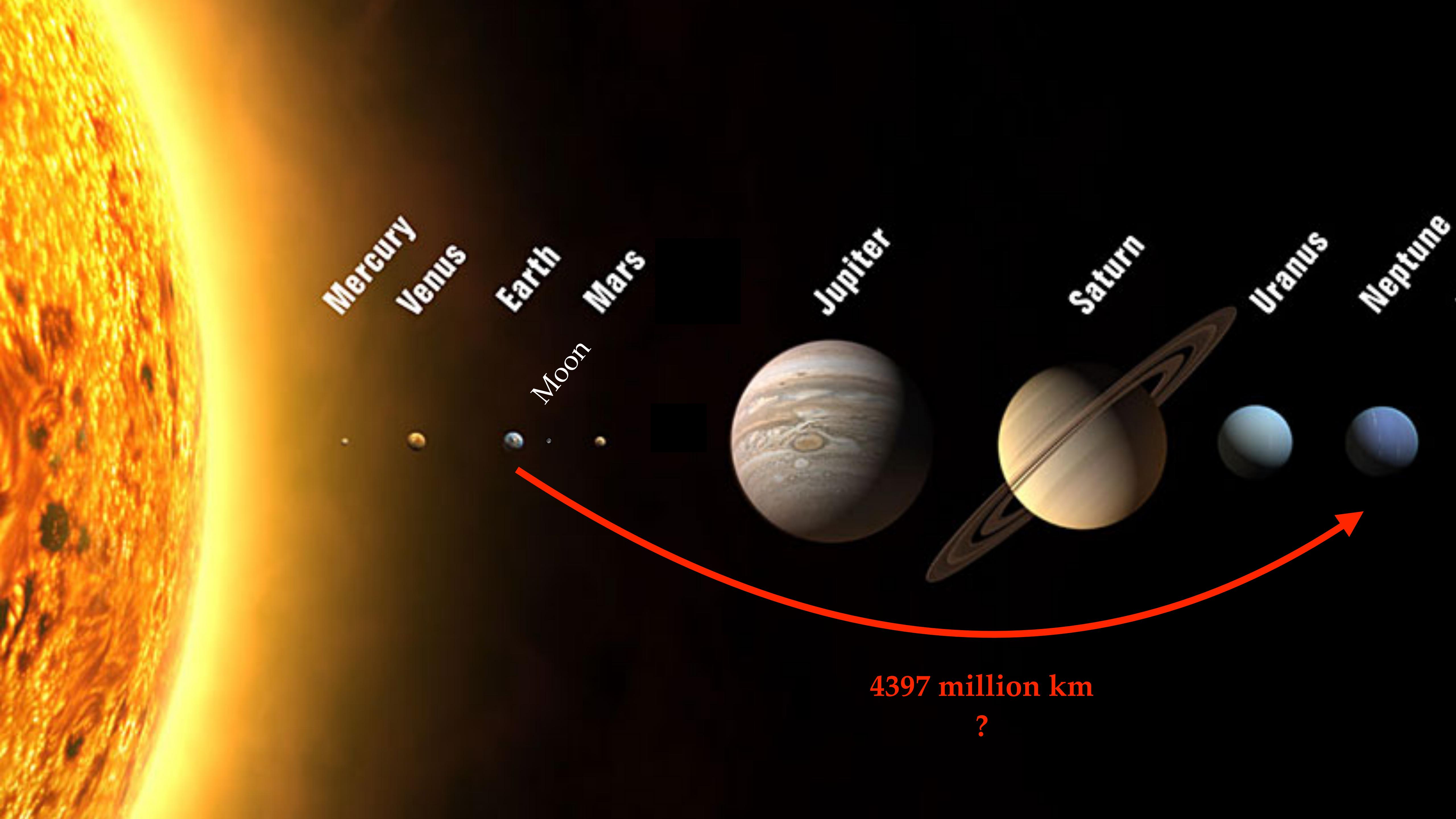
Neptune

225 million km
~ 6 mois



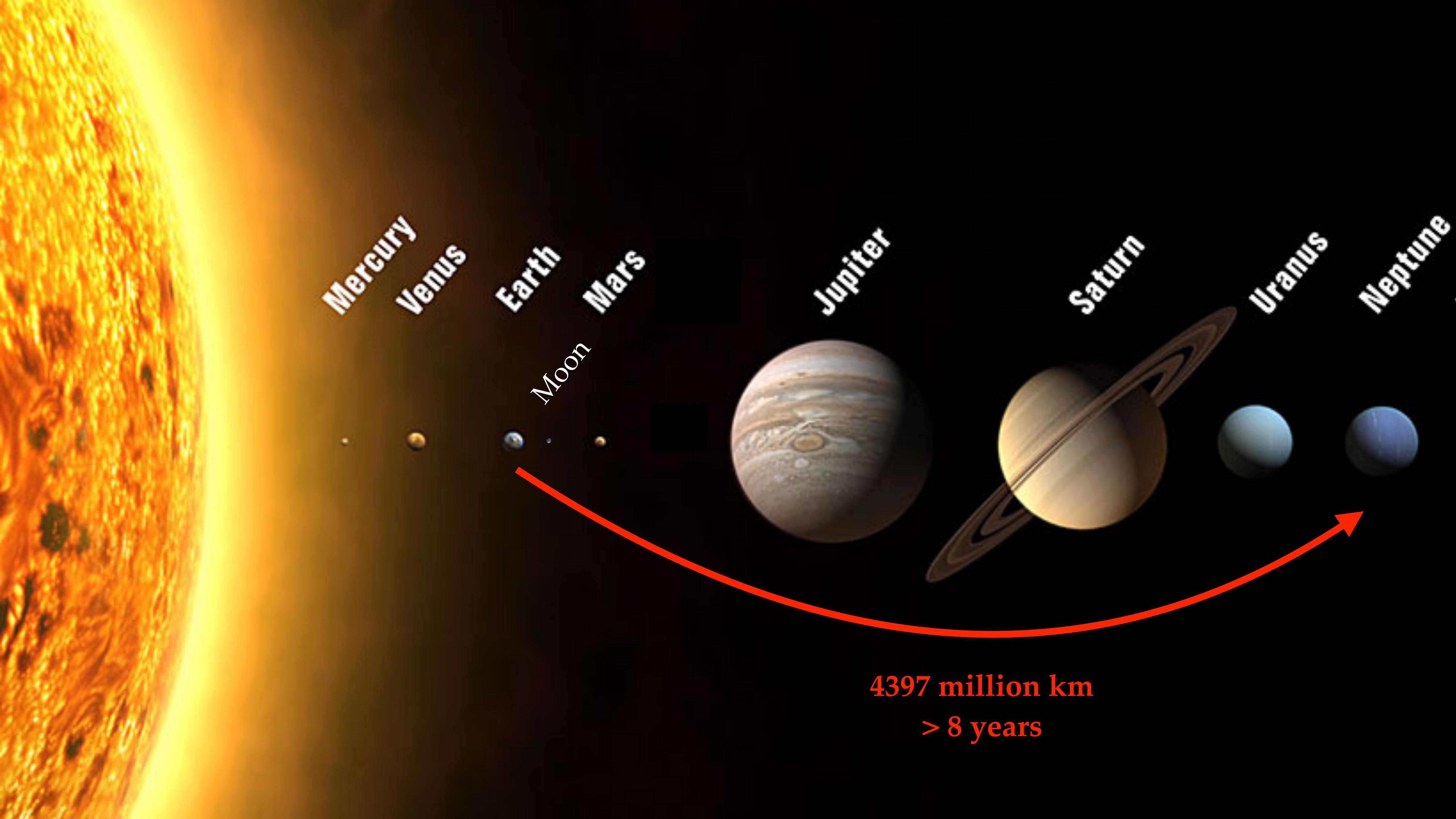
618 million km

~ 13 mois



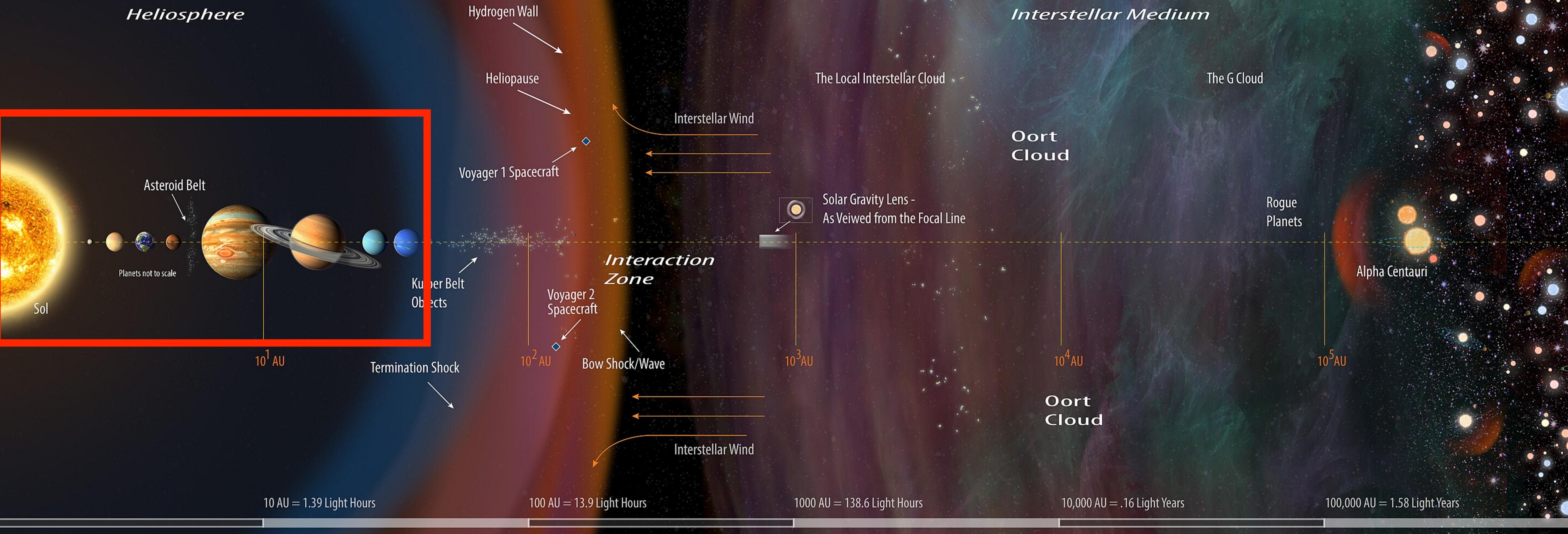
4397 million km

?



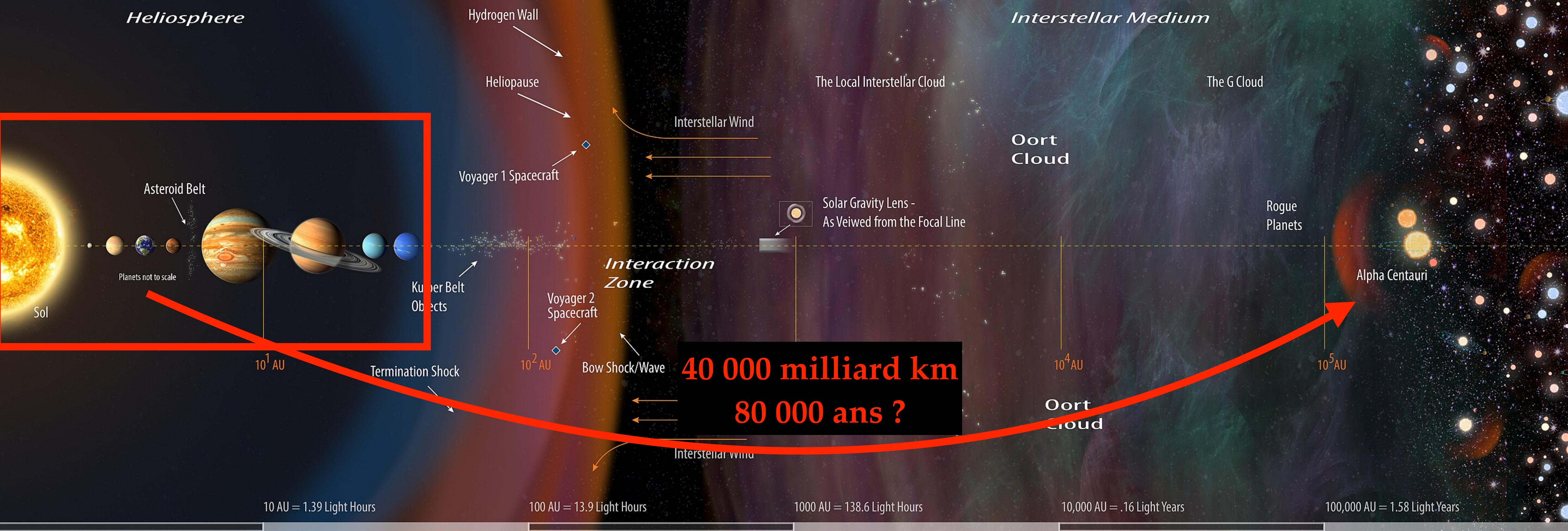
4397 million km
> 8 years

The Interstellar Medium



Échelle logarithmique !

The Interstellar Medium



Échelle logarithmique !

Comment voyager vers Alpha Centauri?

- Voyager plus vite
- Vivre plus longtemps



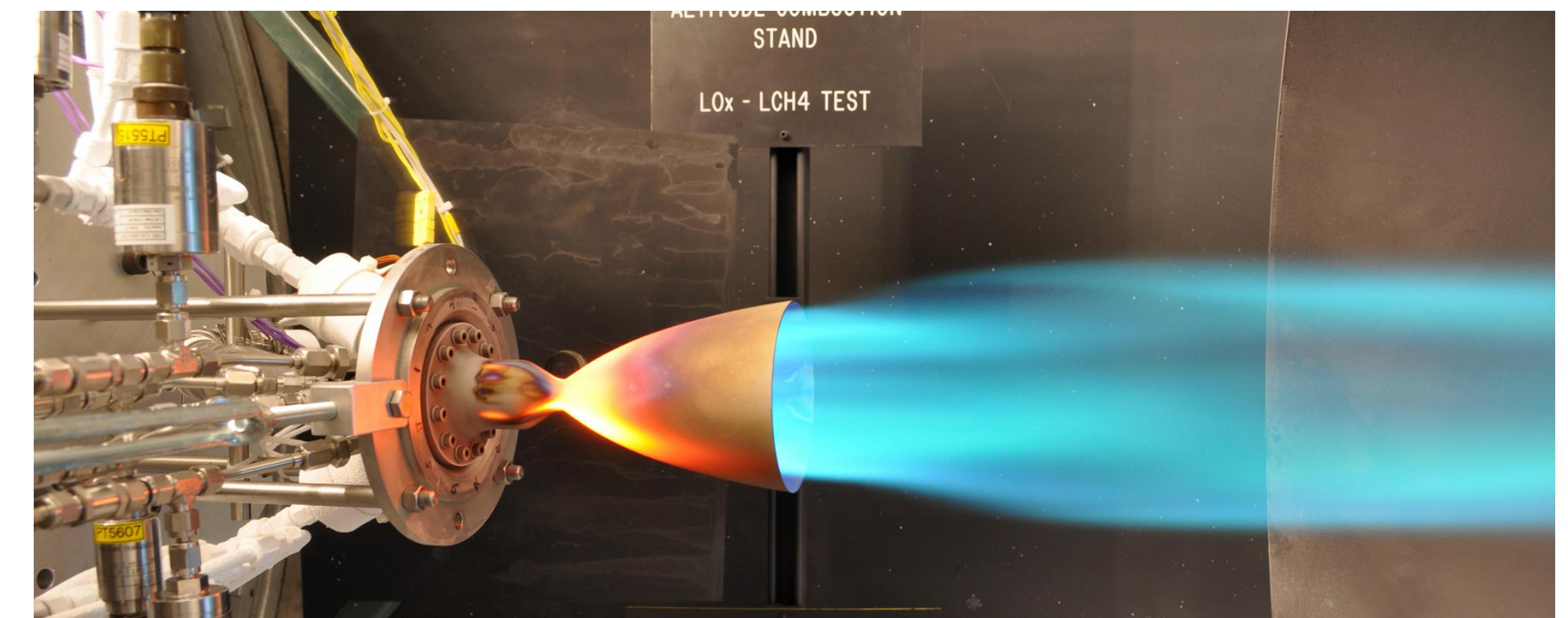
Comment voyager vers Alpha Centauri?

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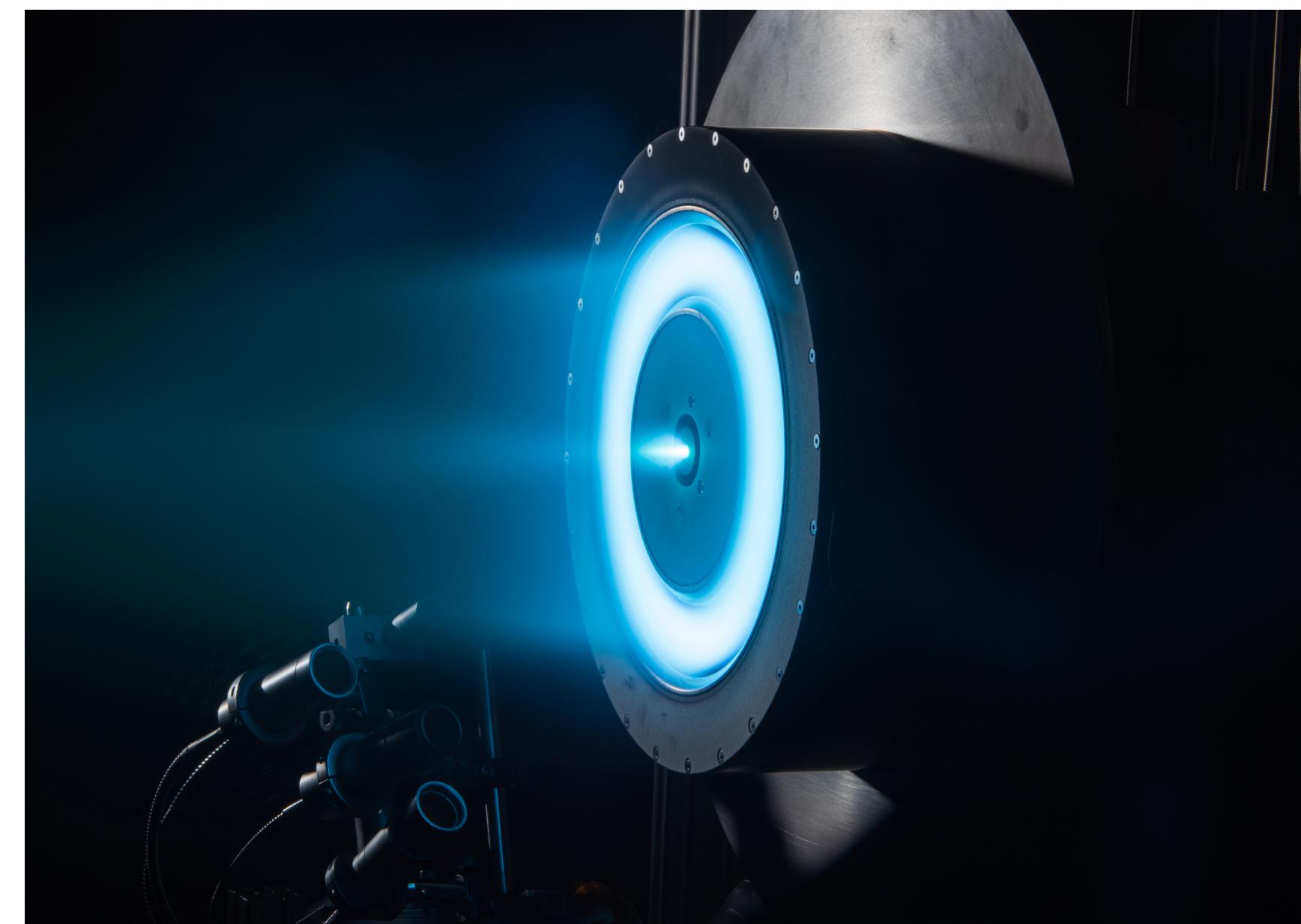
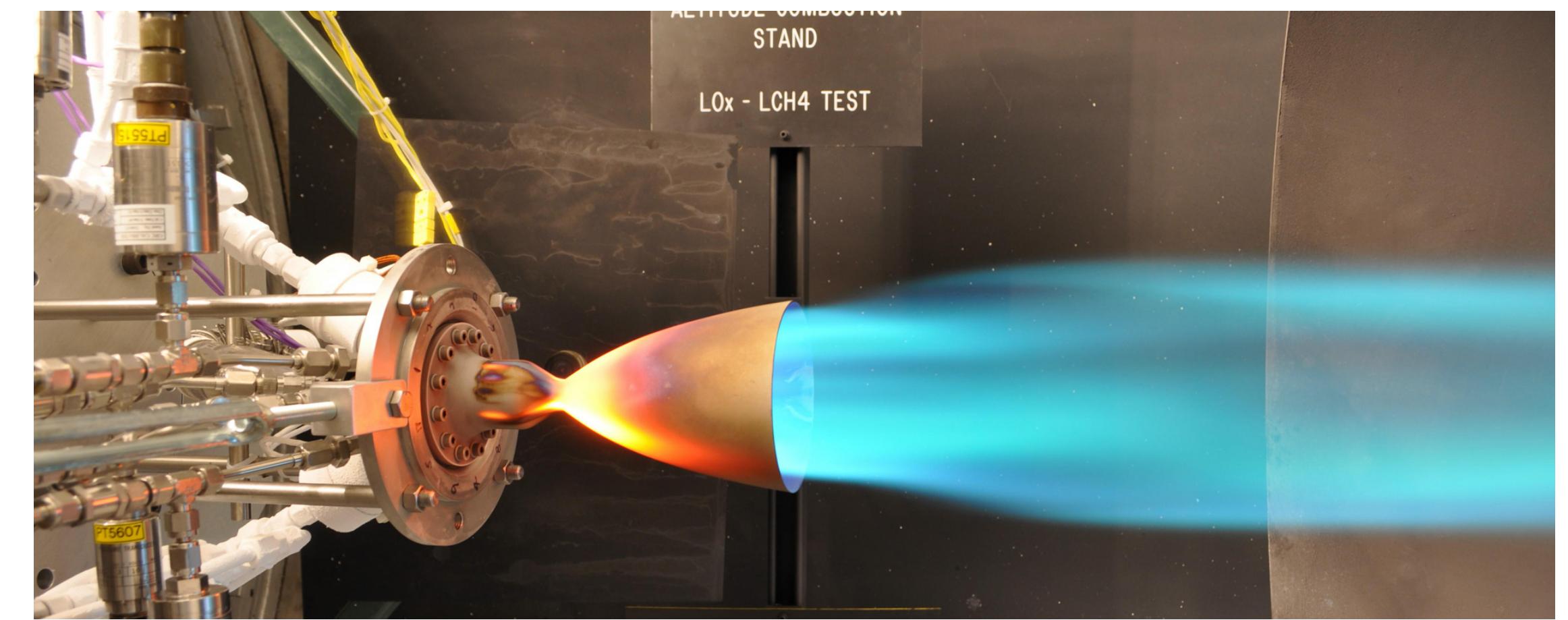
Différents types de propulsion pour les satellites

- Chimique



Différents types de propulsion pour les satellites

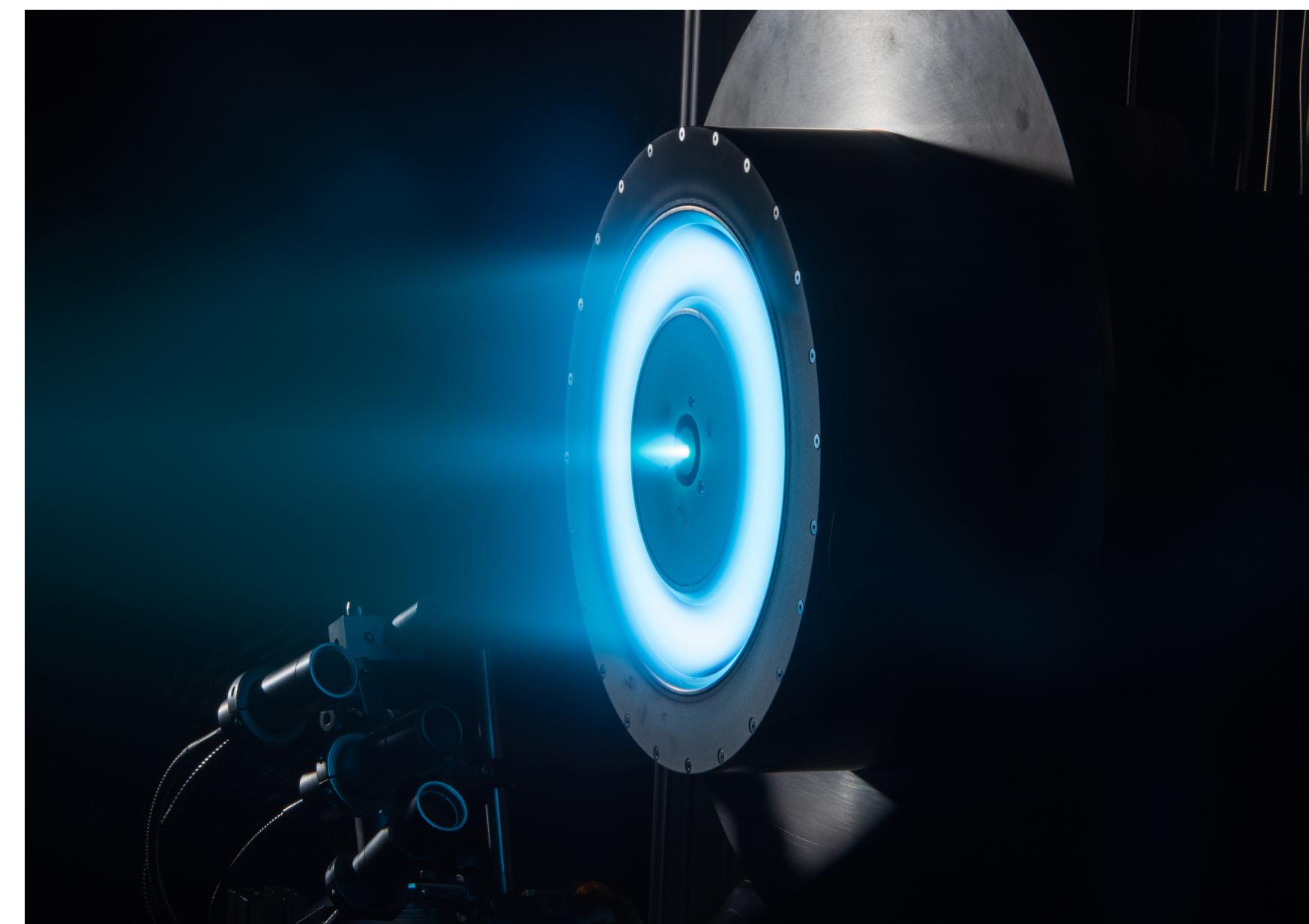
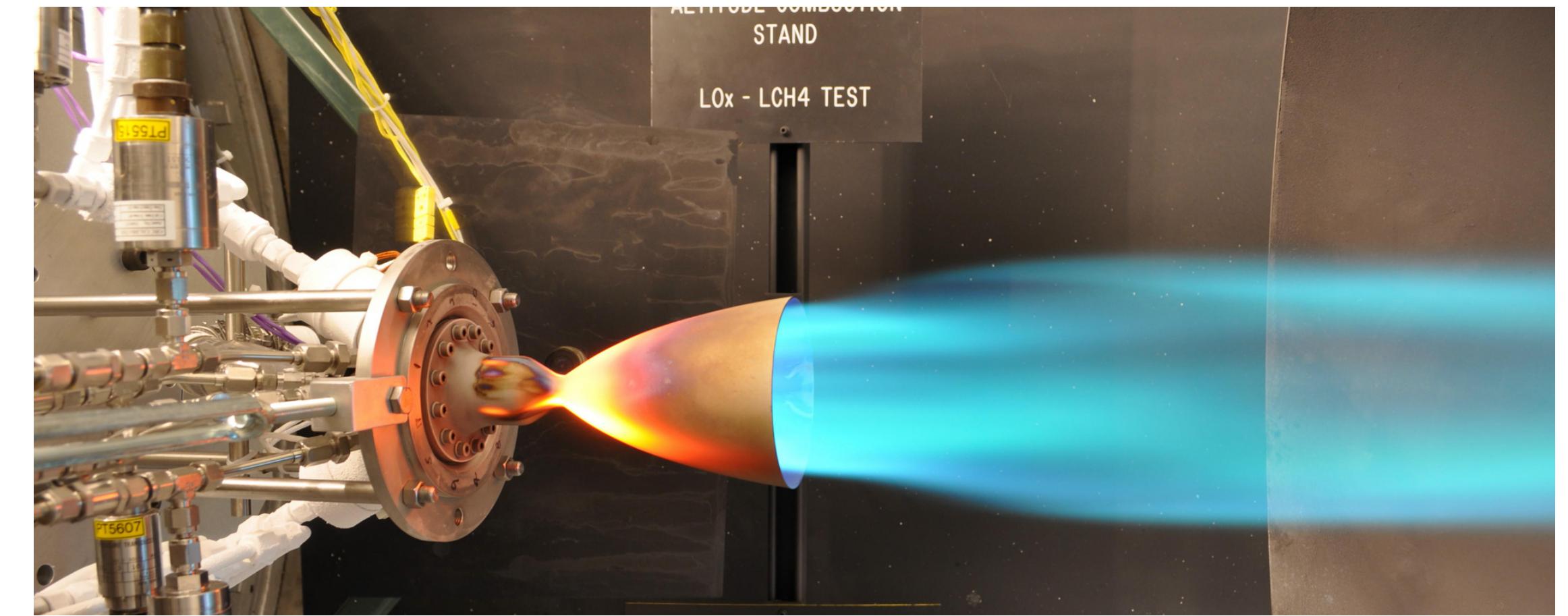
- Chimique
- Électrique



Différents types de propulsion pour les satellites

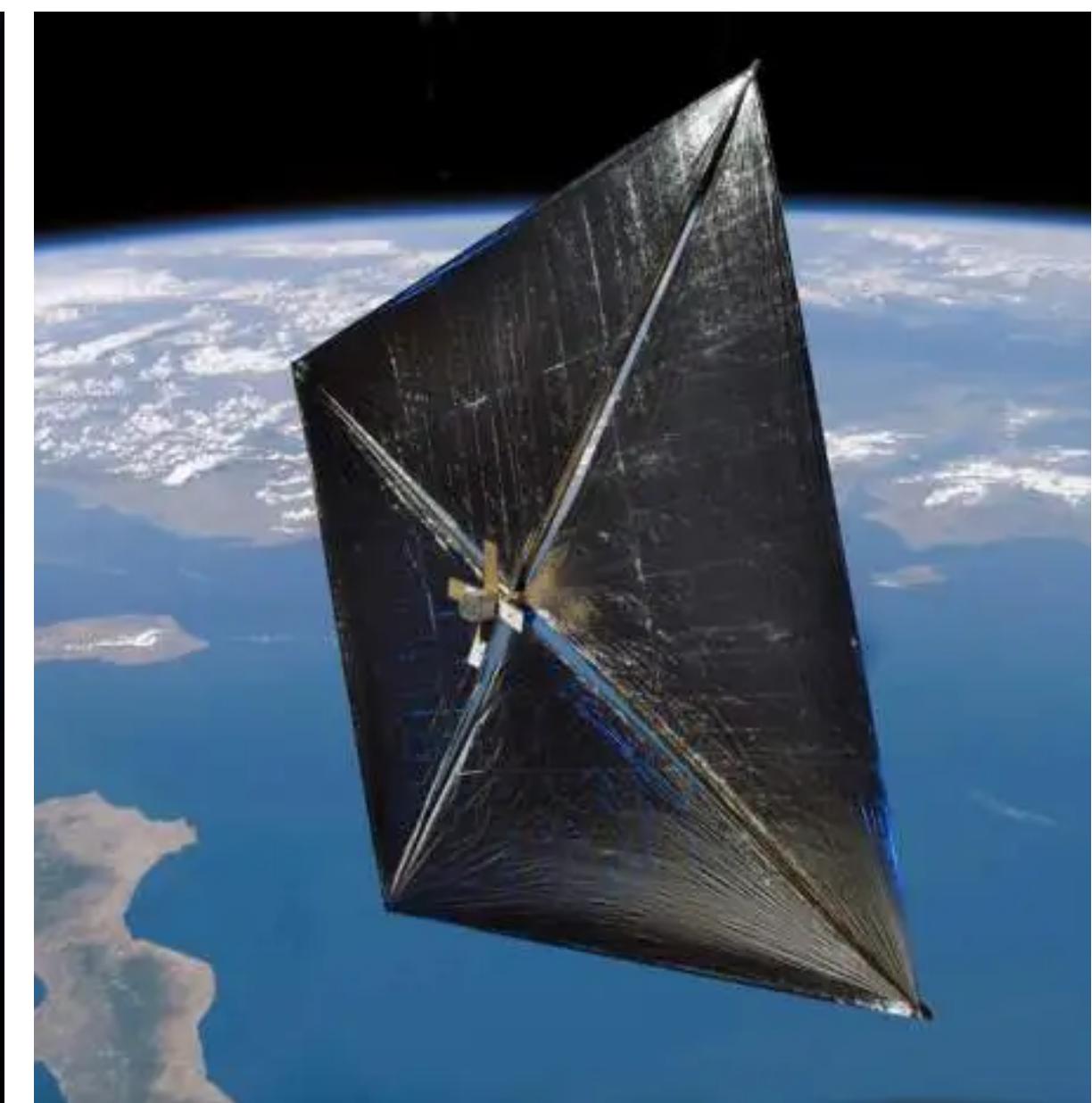
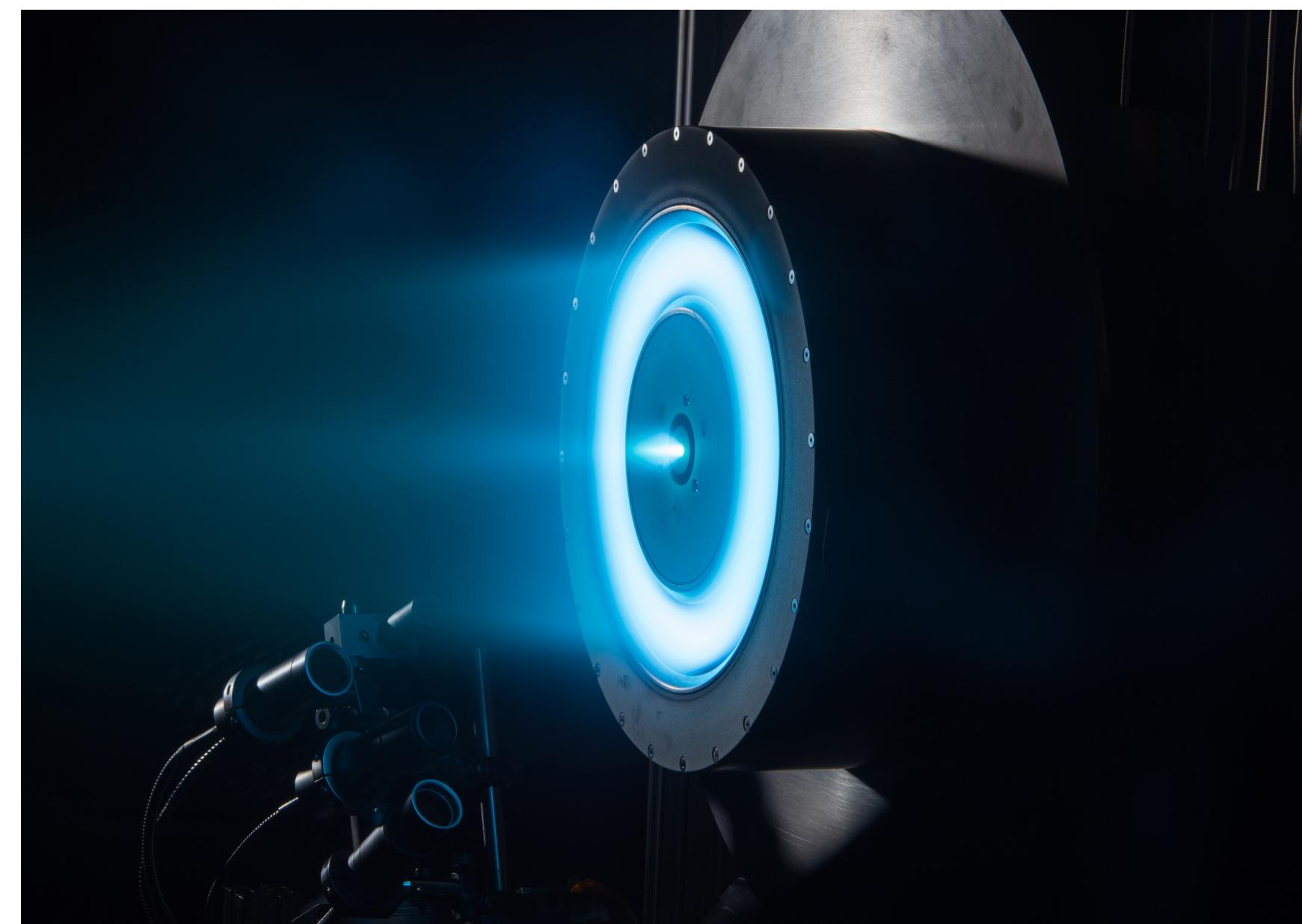
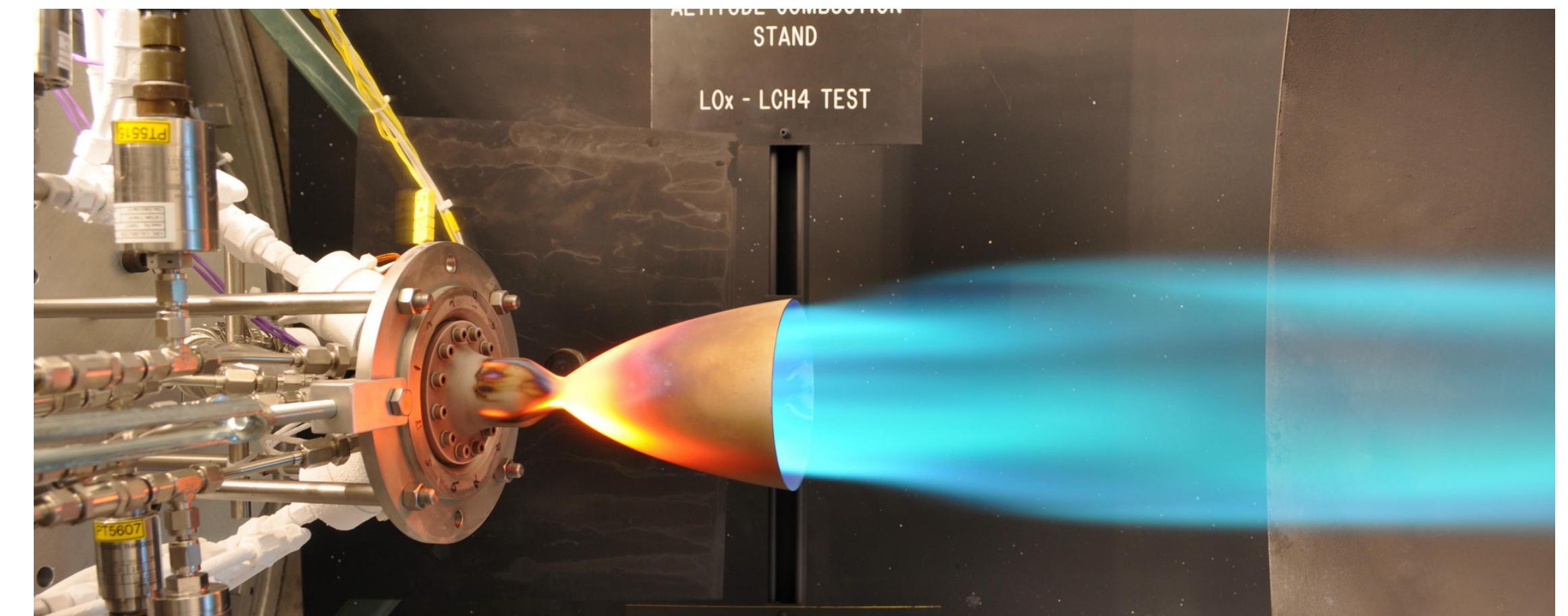
- Chimique
- Électrique

Nécessitent
du carburant
au bord



Différents types de propulsion pour les satellites

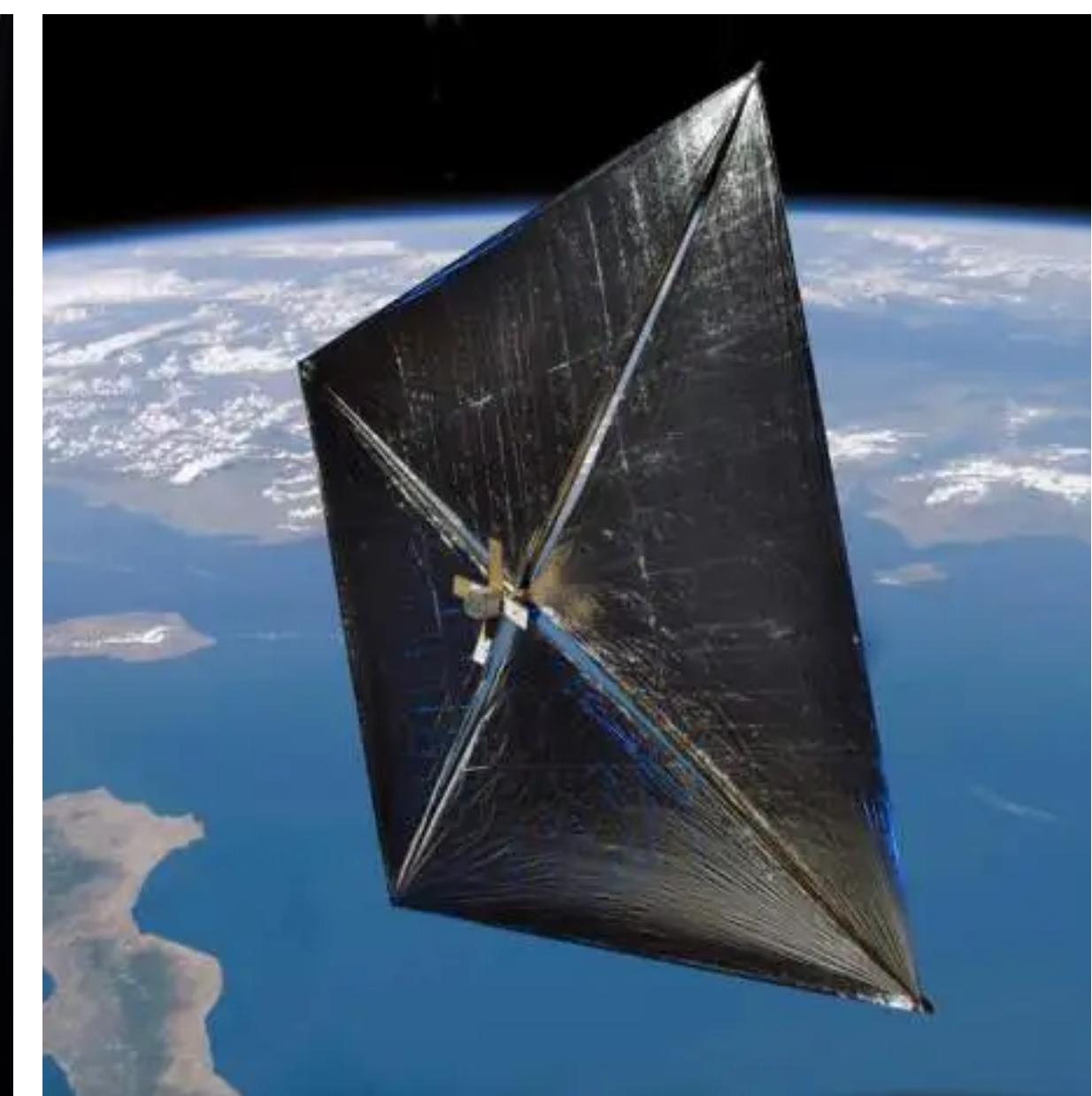
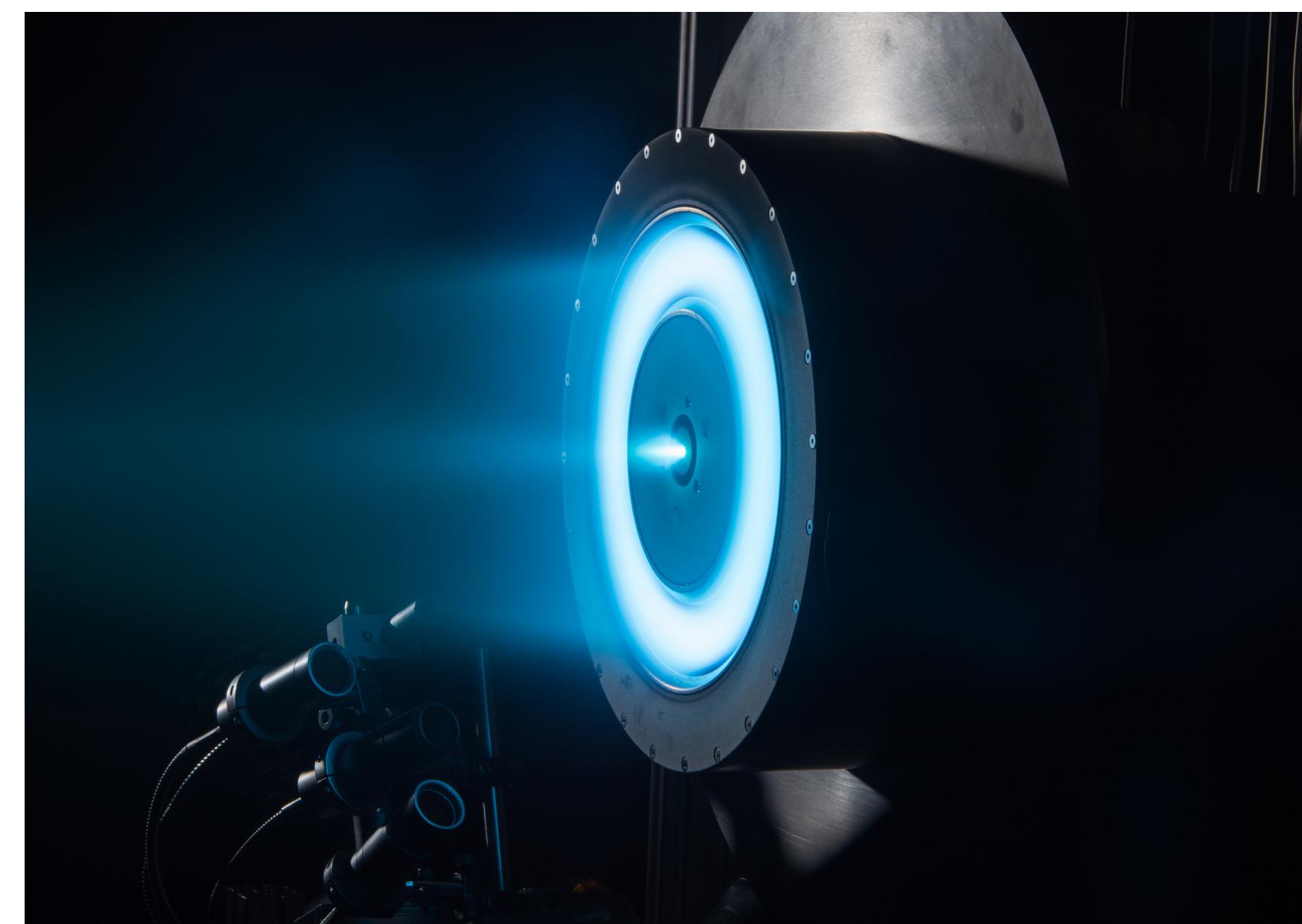
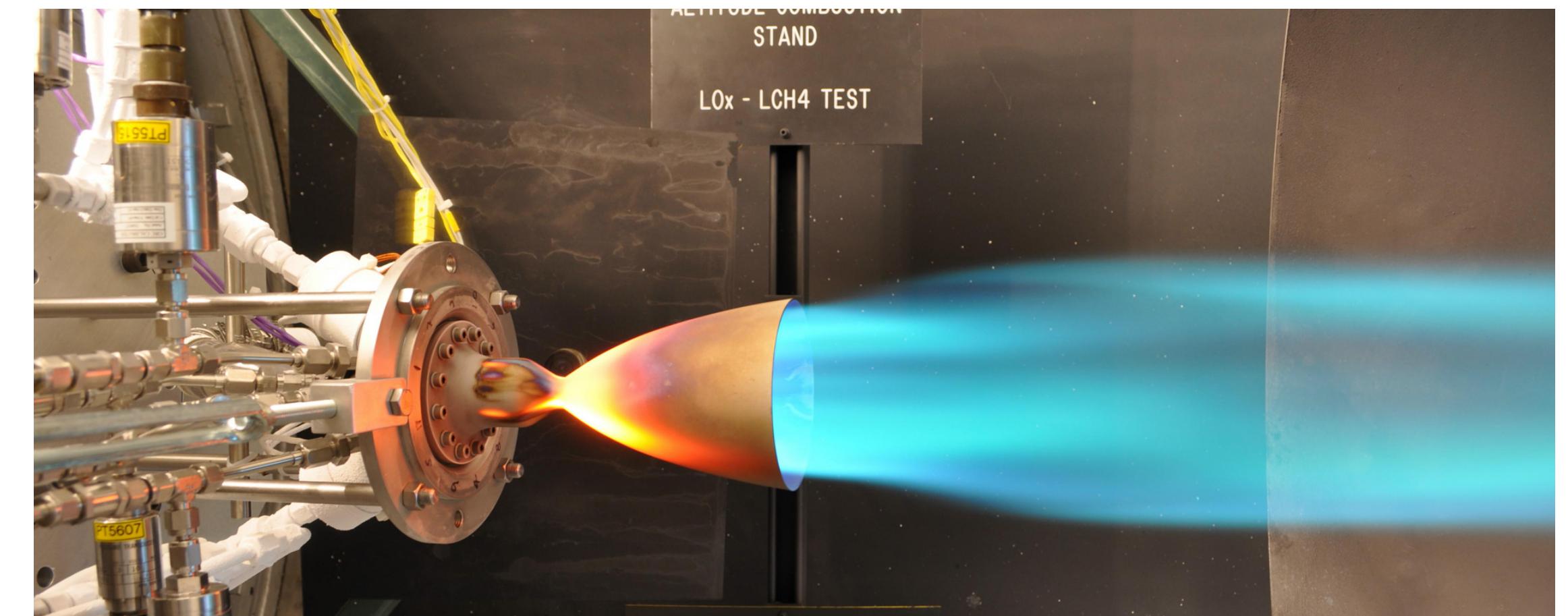
- Chimique
- Électrique
- Sans propergol
(voile solaire)



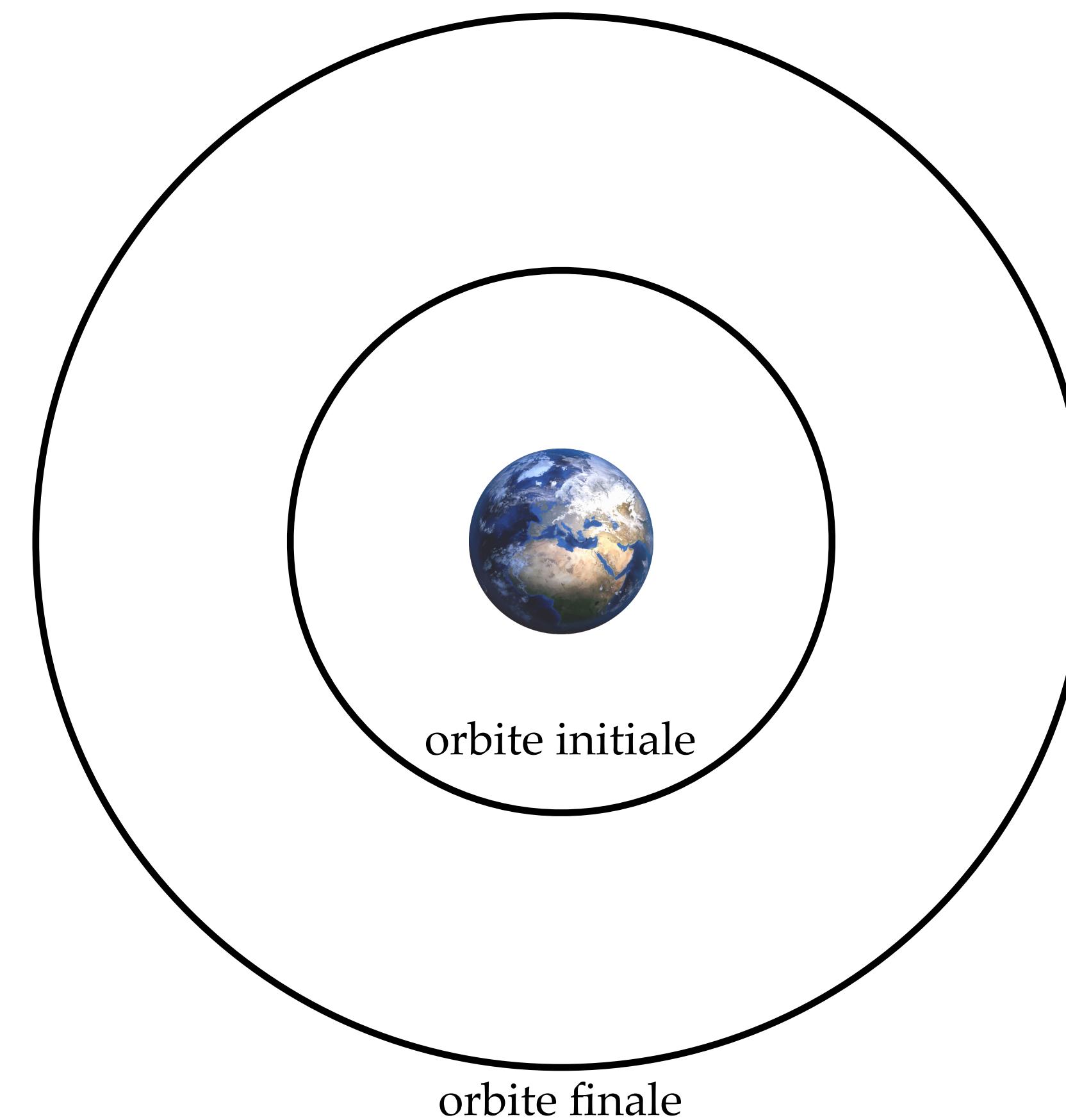
Différents types de propulsion pour les satellites

- Chimique
- Électrique
- Sans propergol
(voile solaire)

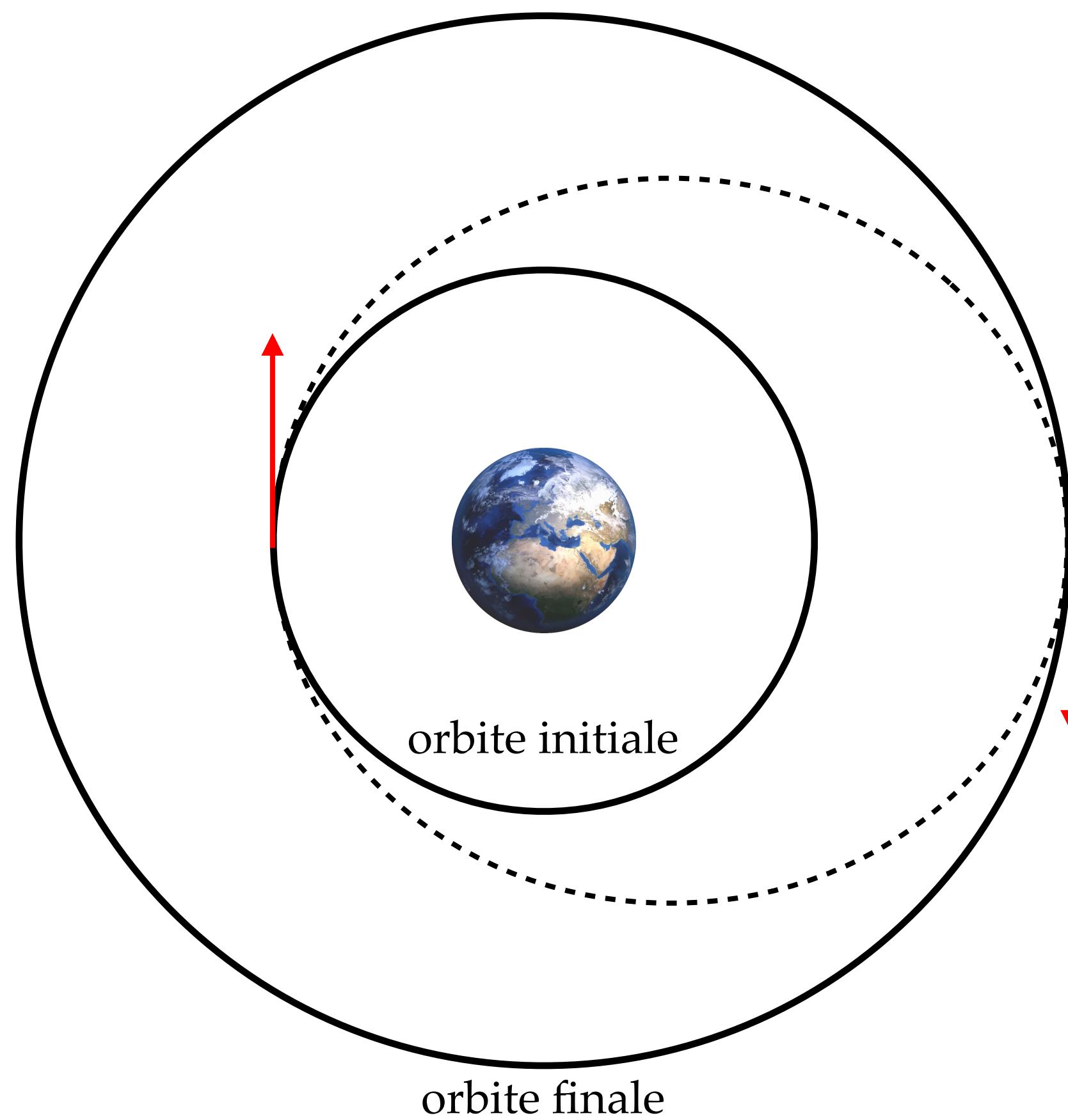
Propulsion
faible



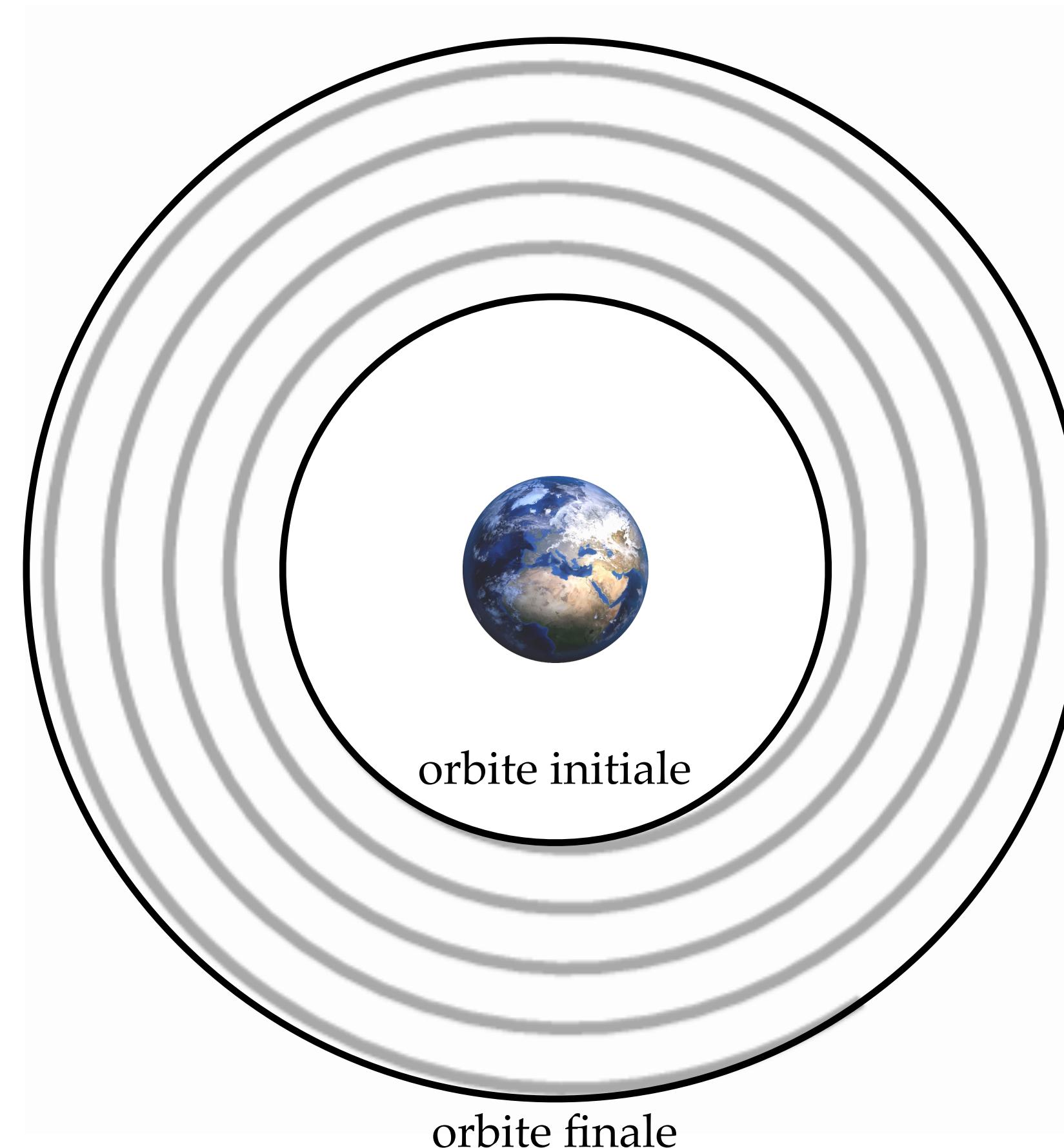
Comment augmenter l'altitude orbitale?



Propulsion chimique



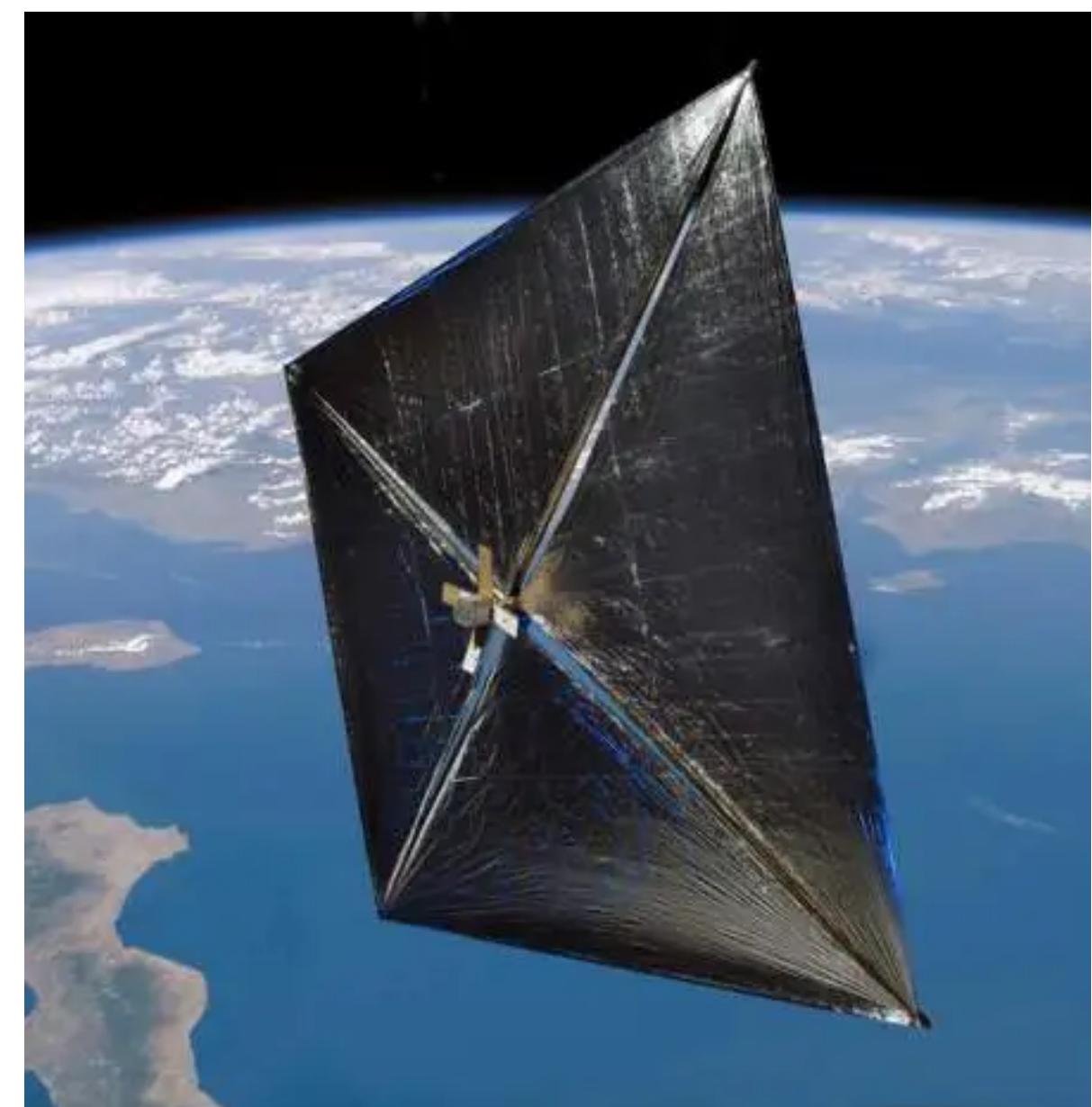
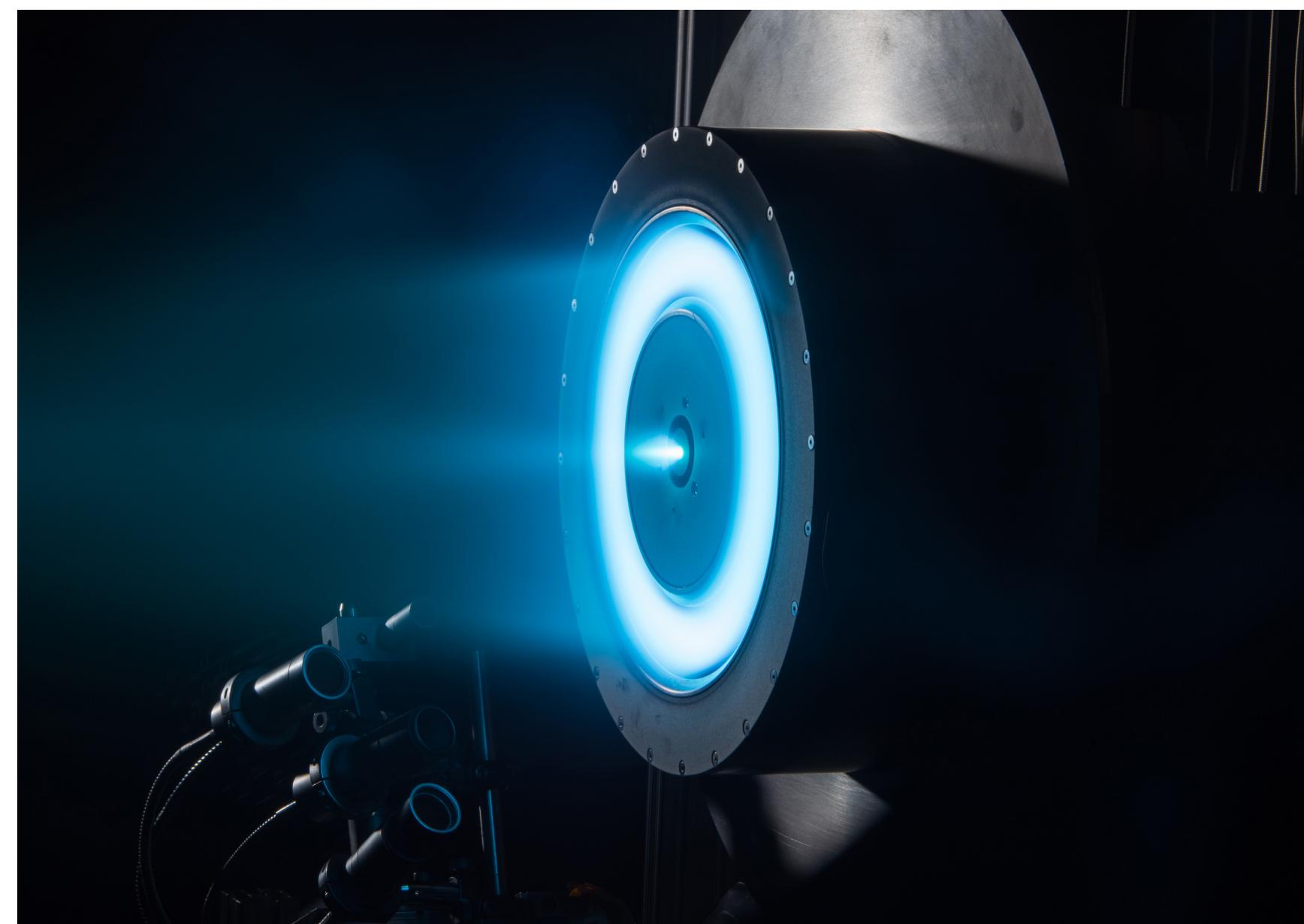
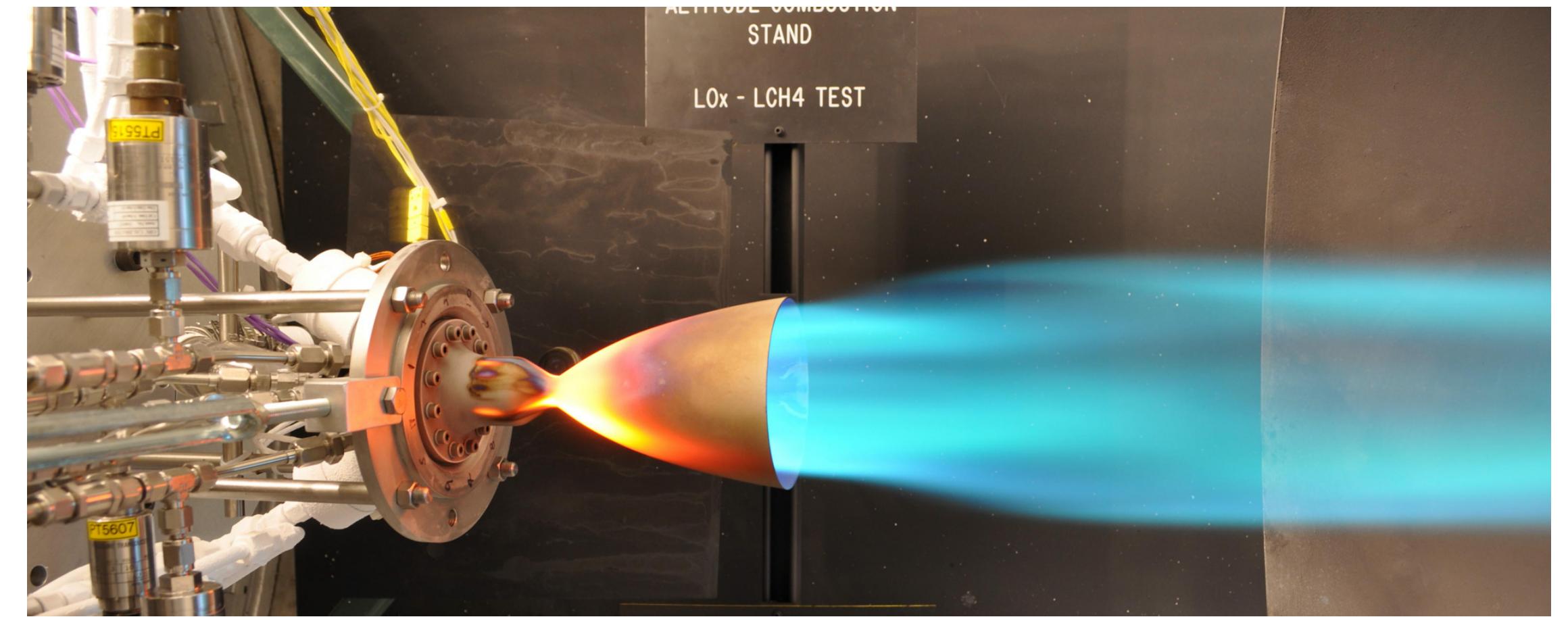
Faible poussée

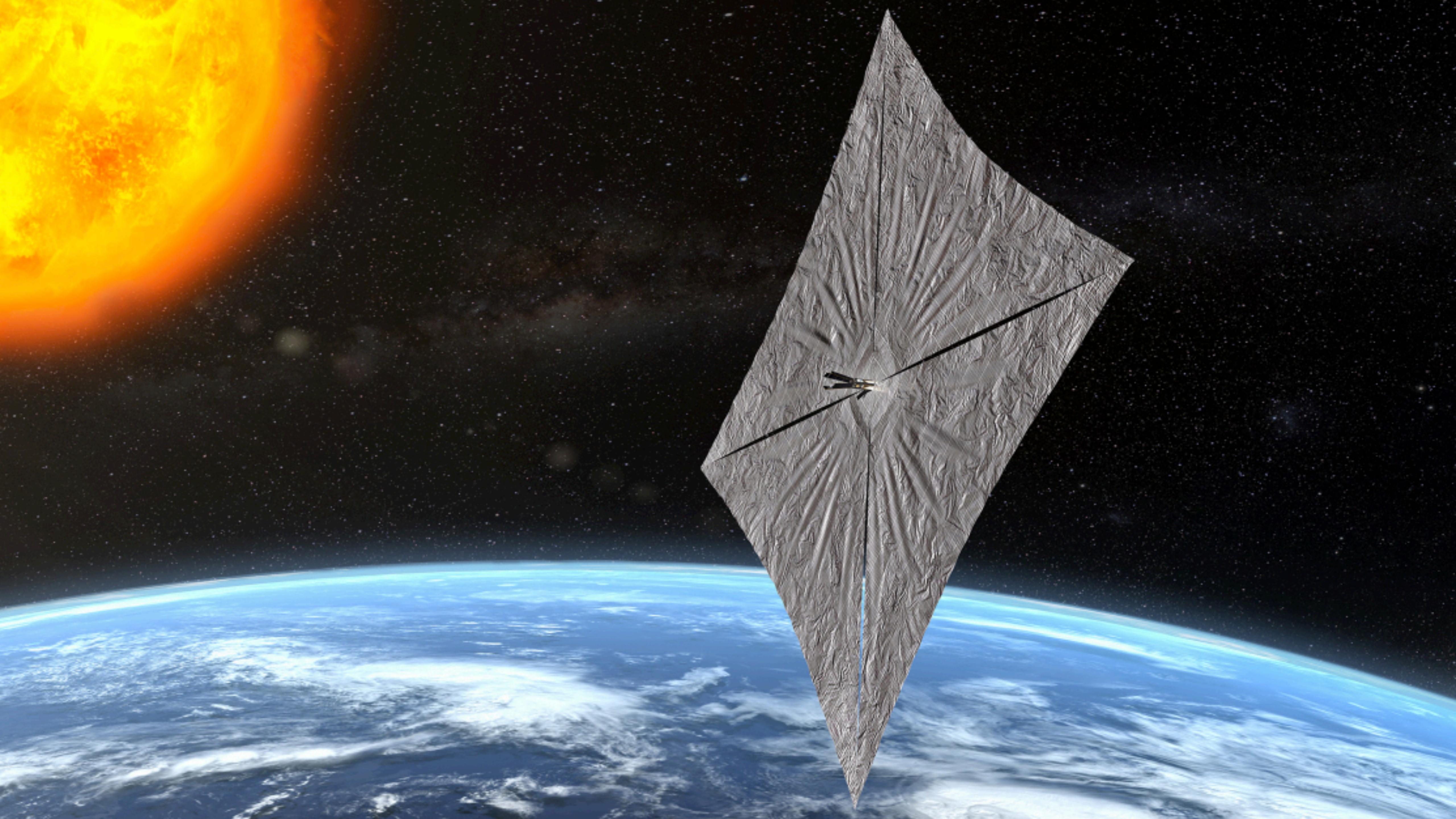


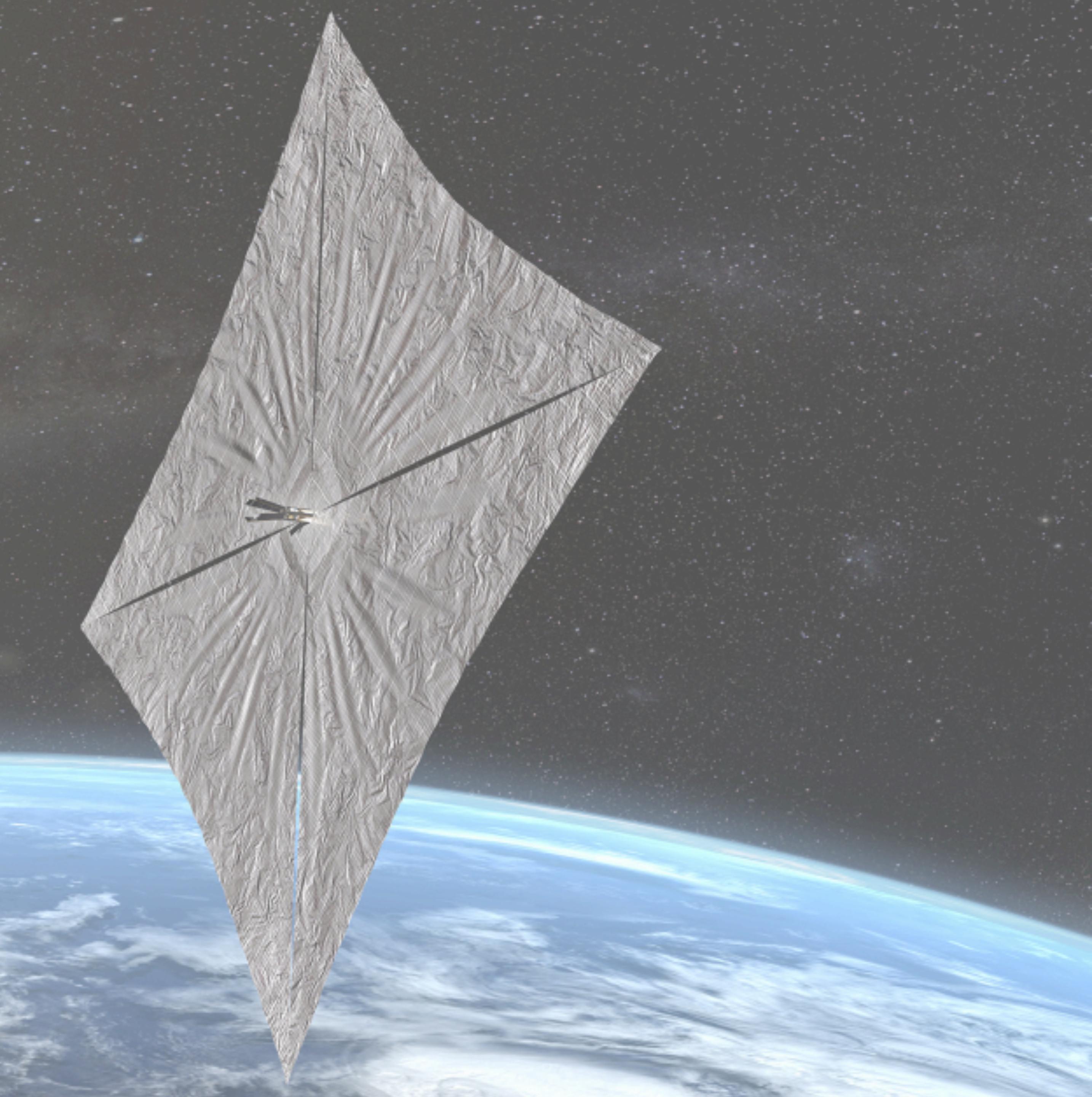
manœuvres multi-révolution

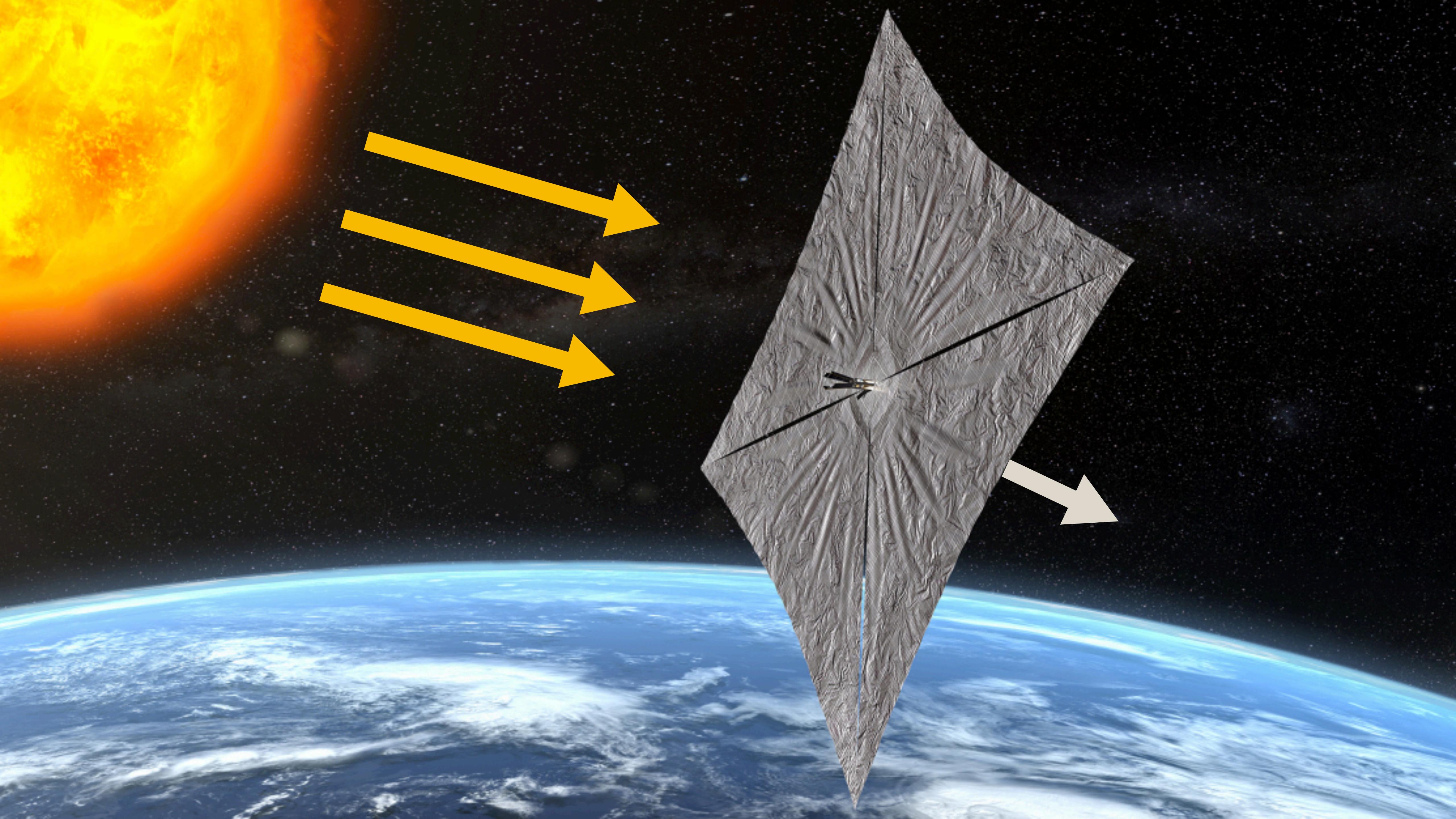
Différents types de propulsion pour les satellites

- Chimique
- Électrique
- Sans propergol
(voile solaire)
- Propulsion nucléaire ?

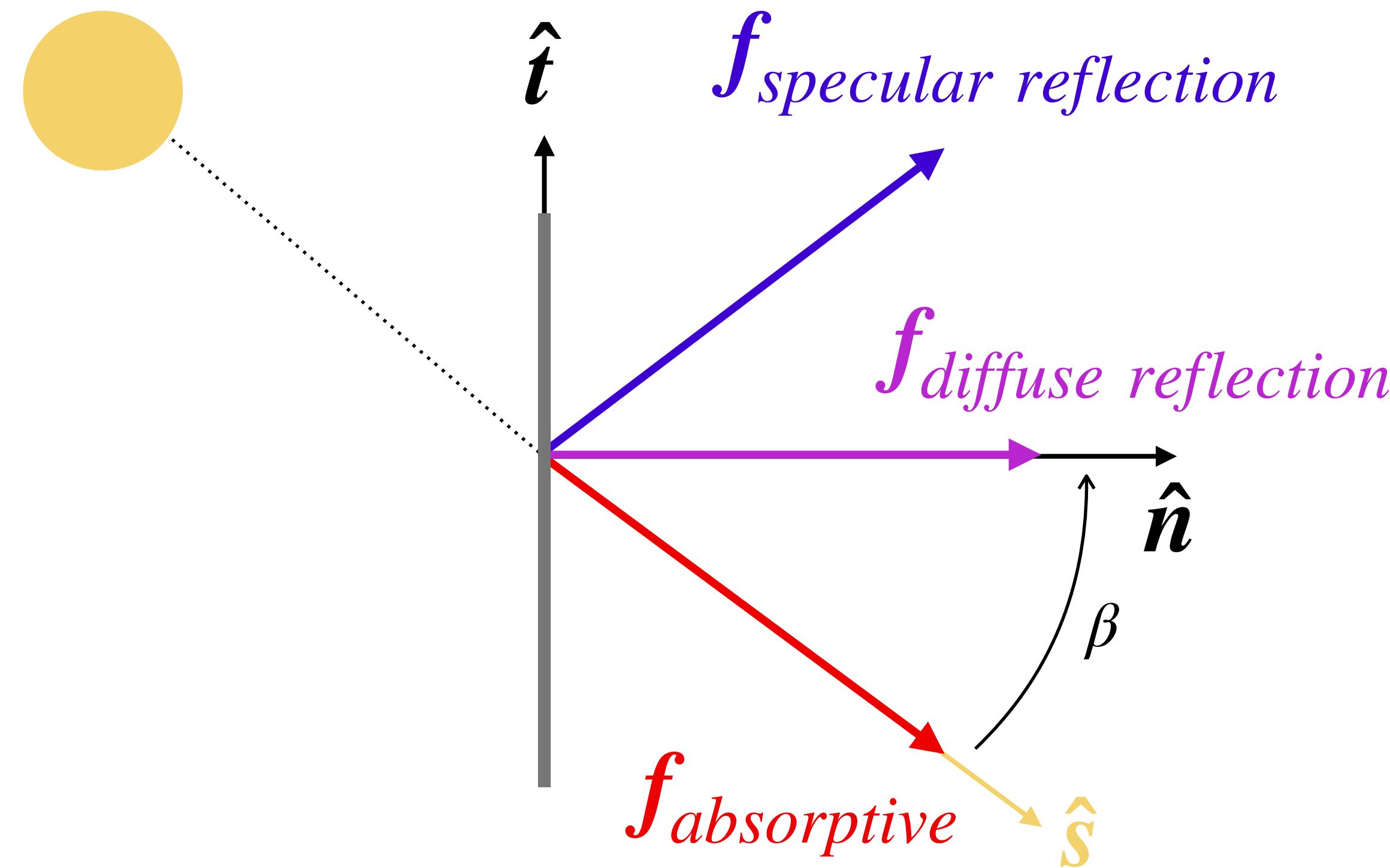






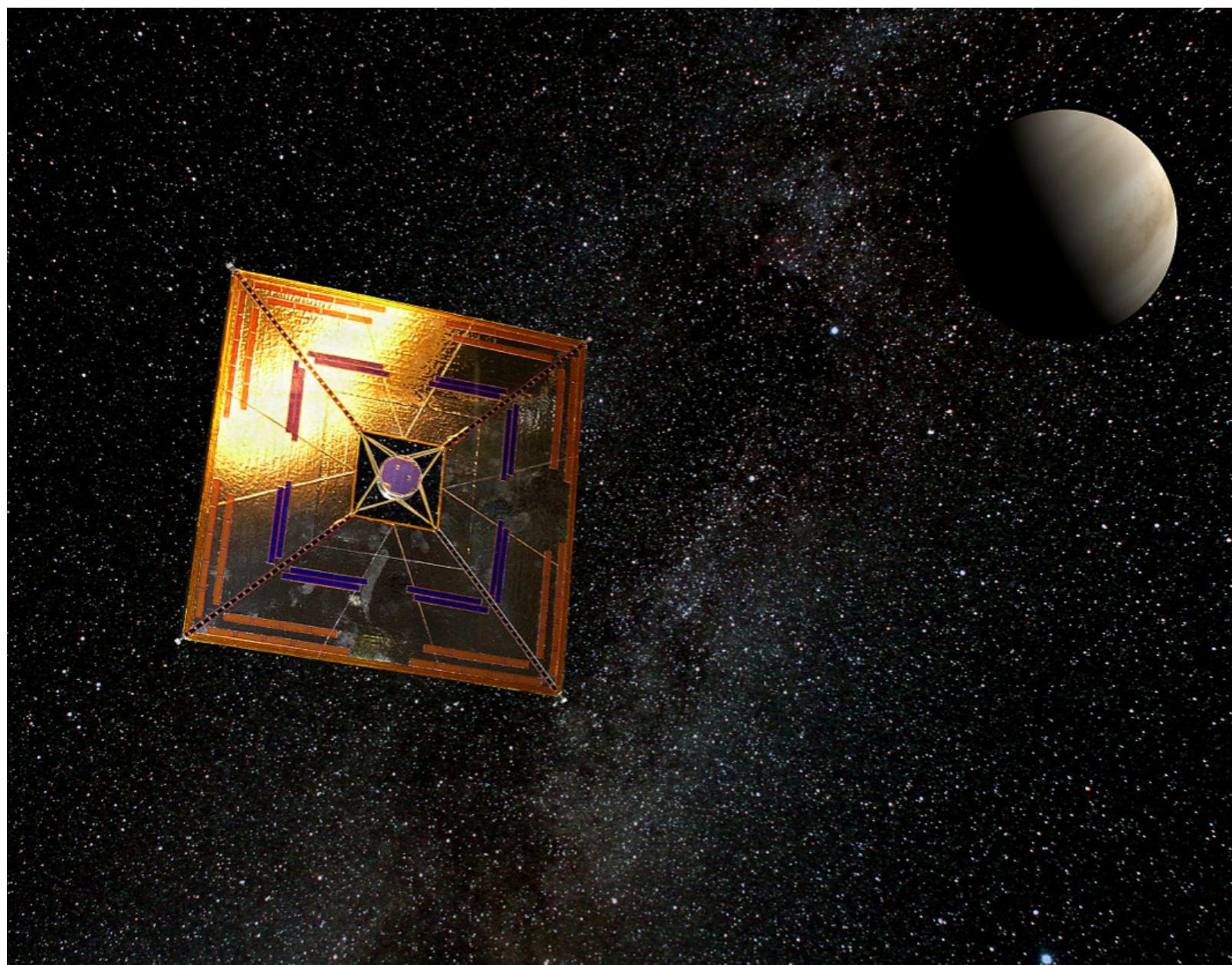


Force de la pression de radiation solaire

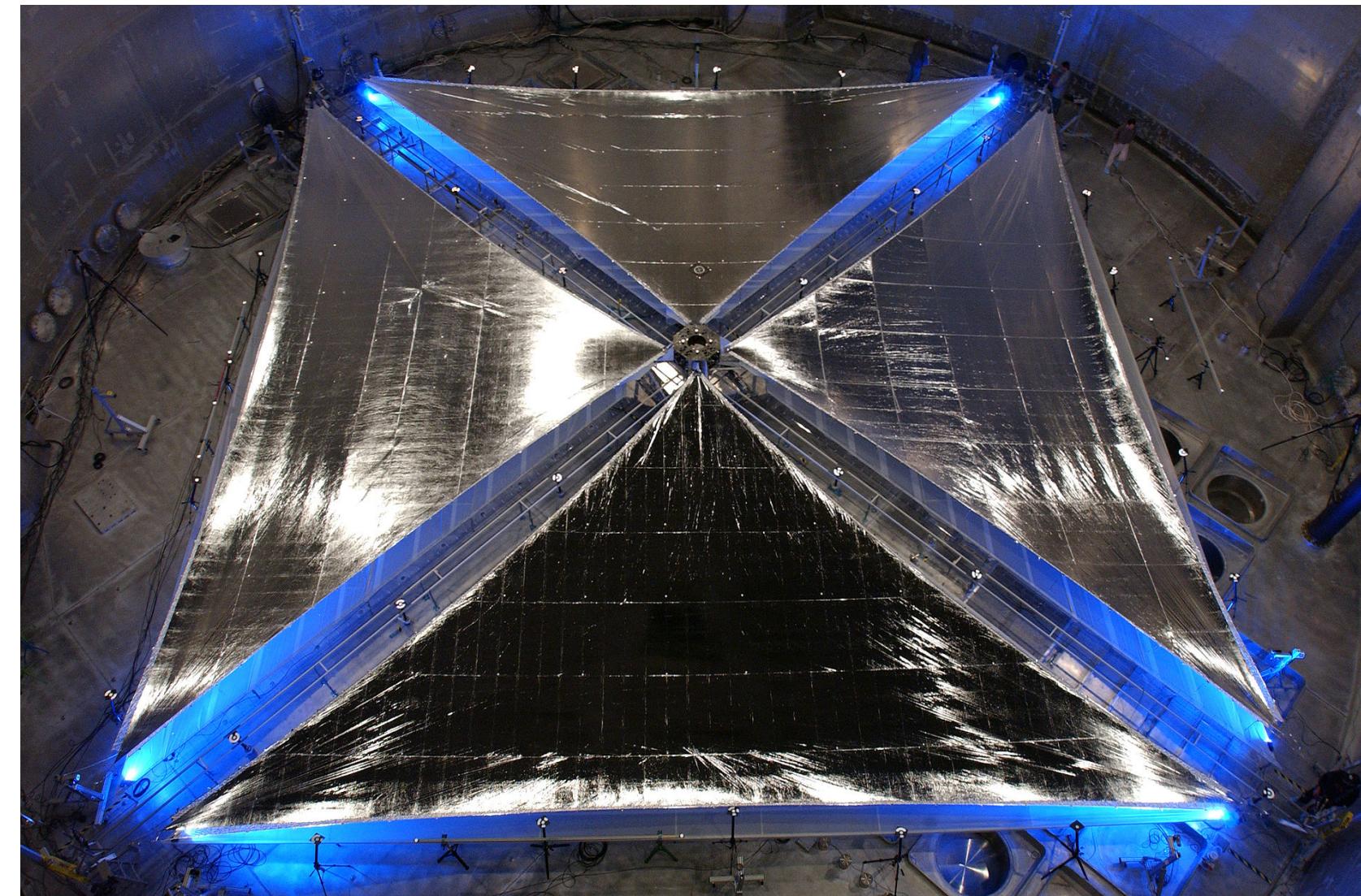


$$f_{SRP} = f_{absorptive} + f_{specular reflection} + f_{diffuse reflection}$$

Premières missions démonstratrices

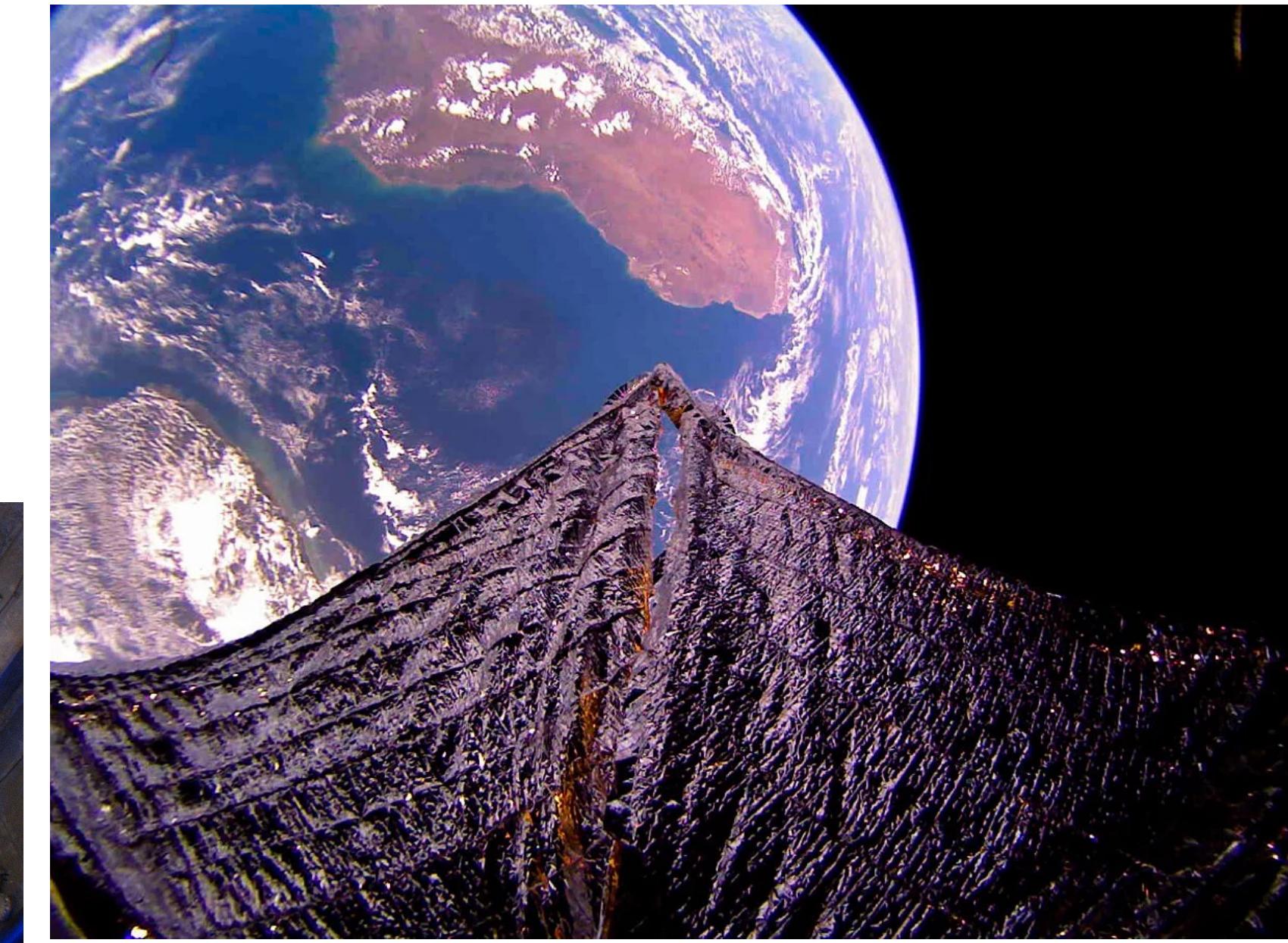


IKAROS, 2010
JAXA
 $196\ m^2$



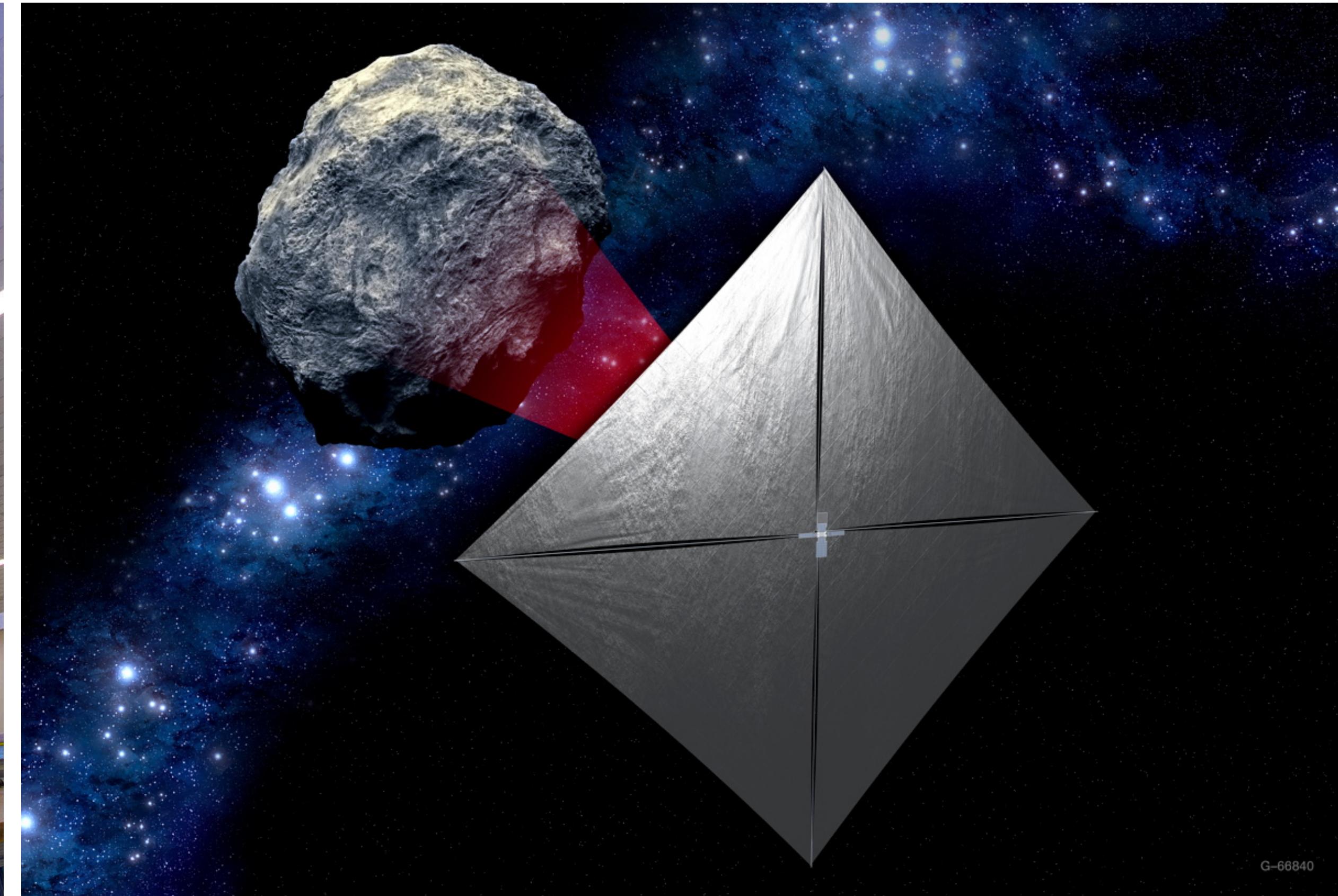
(Prototype similar to LS-1)

LightSail-1, 2015
Planetary Society
 $32\ m^2$



LightSail-2, 2019
Planetary Society
 $32\ m^2$

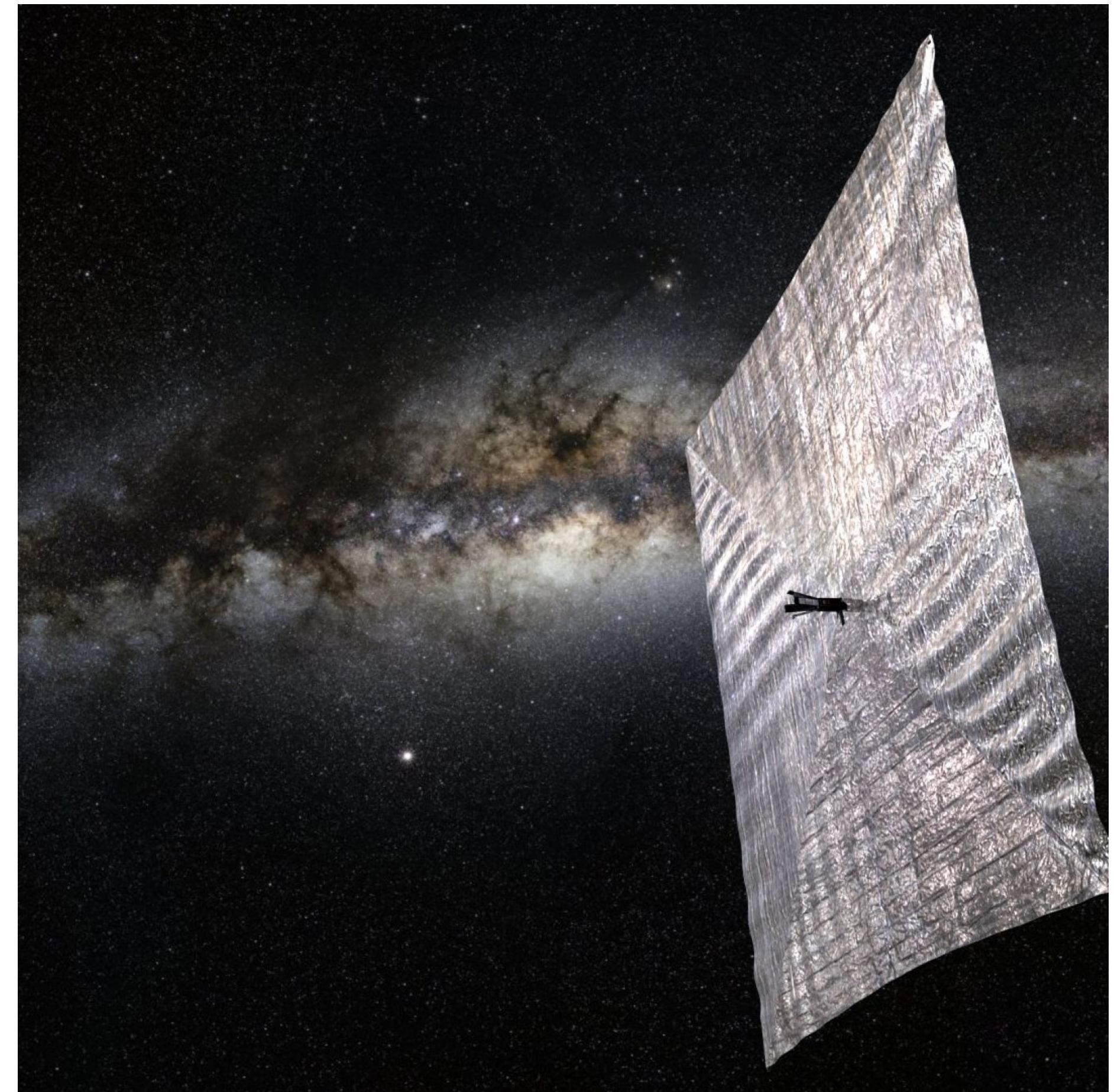
Aujourd’hui, les voiles permettent des nouvelles missions ambitieuses



NEA-Scout, 2022
NASA
 $85\ m^2$

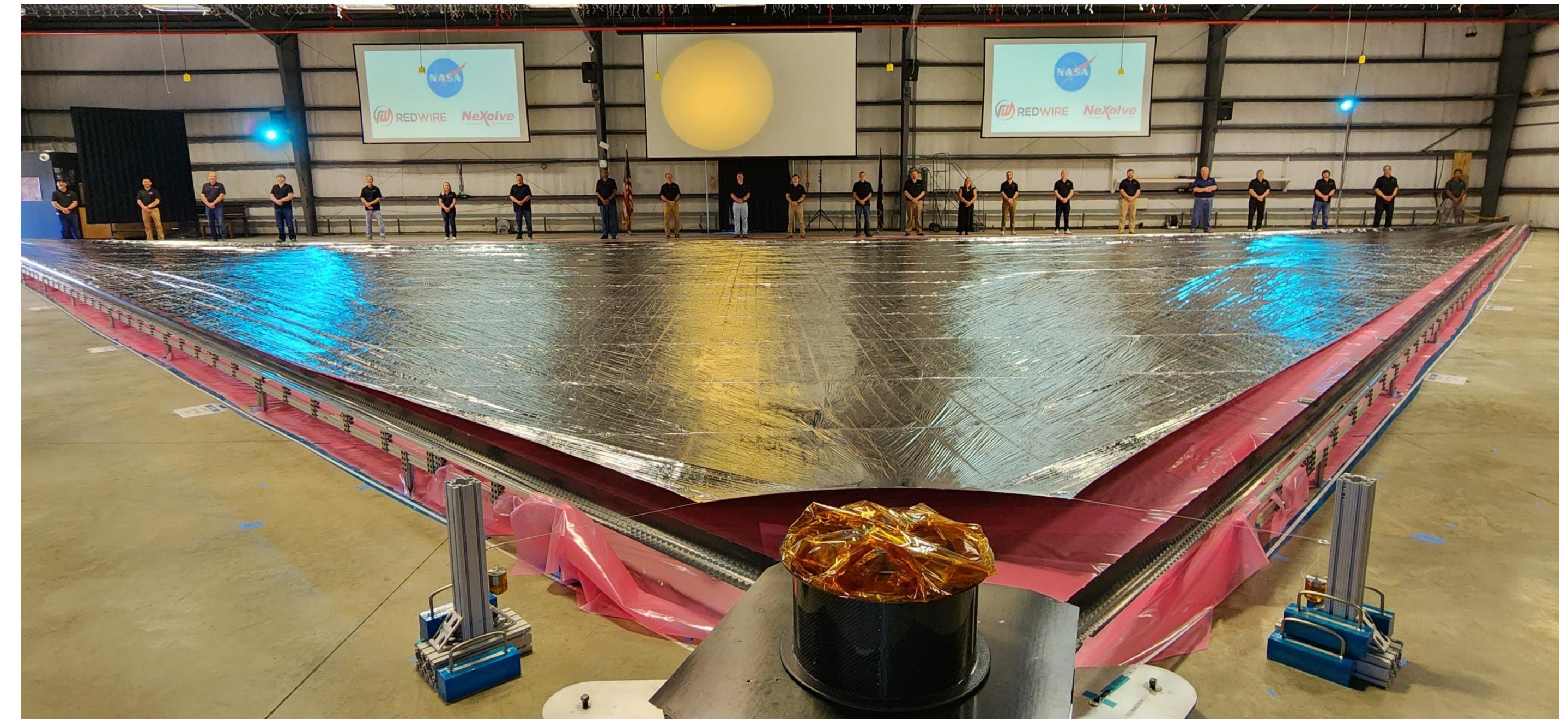
Demain: aller au-delà du système solaire?

Déjà avec les technologies d'aujourd'hui : 33 km / s



Comment améliorer les performances de la voile?

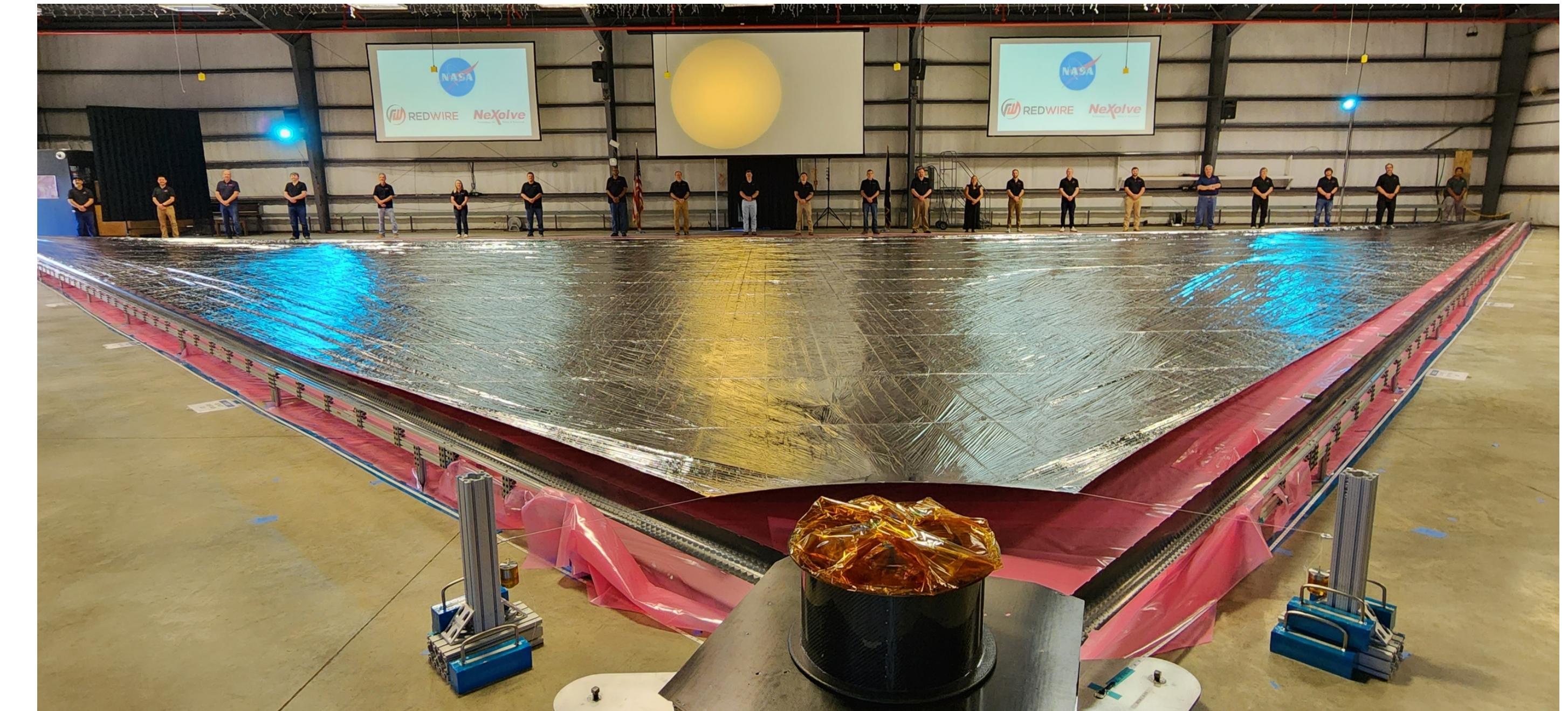
- Des voiles plus grandes
- Des matériaux plus légers



Solar Cruiser

Comment améliorer les performances de la voile?

- Des voiles plus grandes
- Des matériaux plus légers



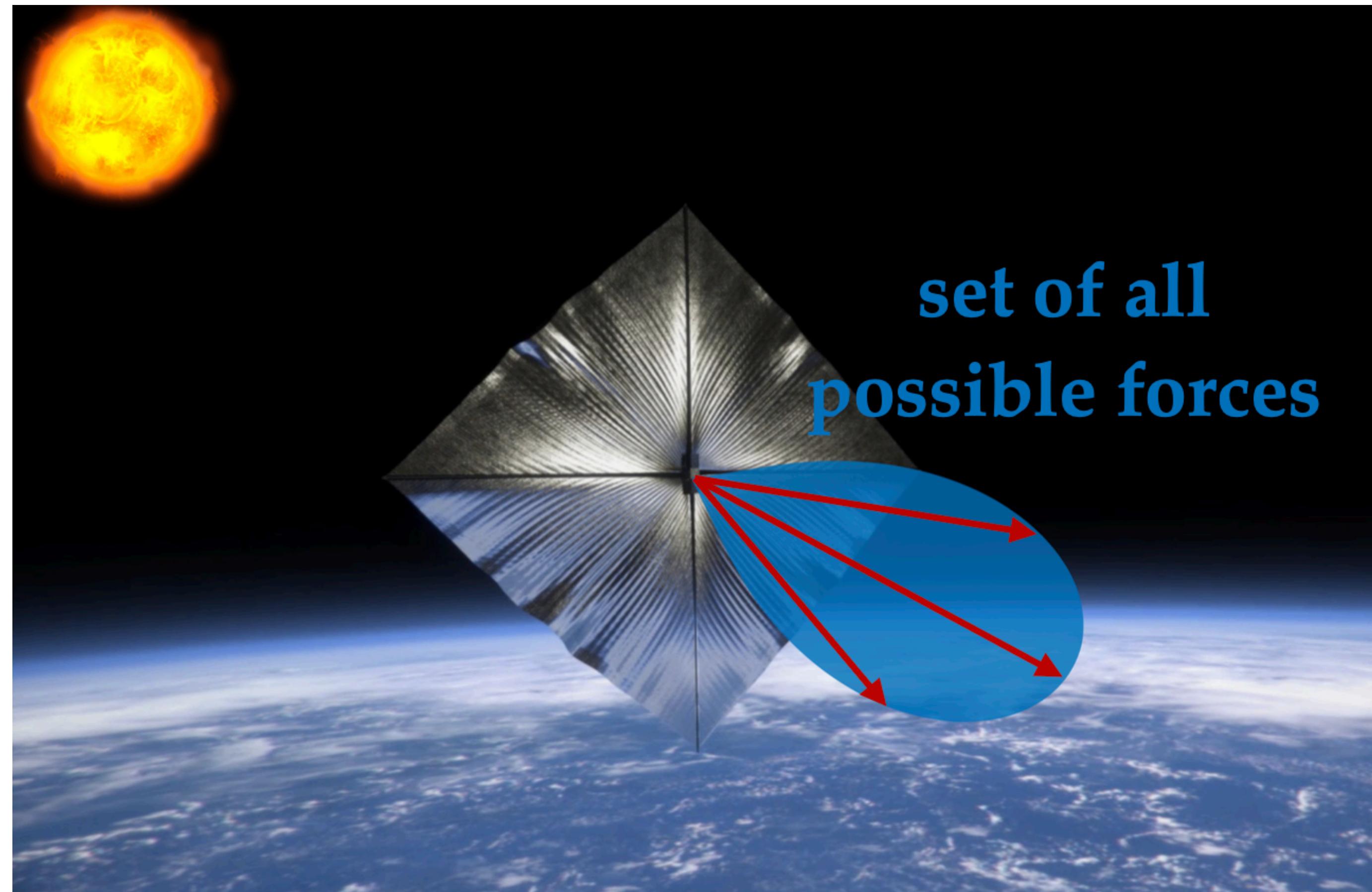
- Analyser les manœuvres possibles à effectuer avec une voile
- Design des trajectoires optimales

Solar Cruiser

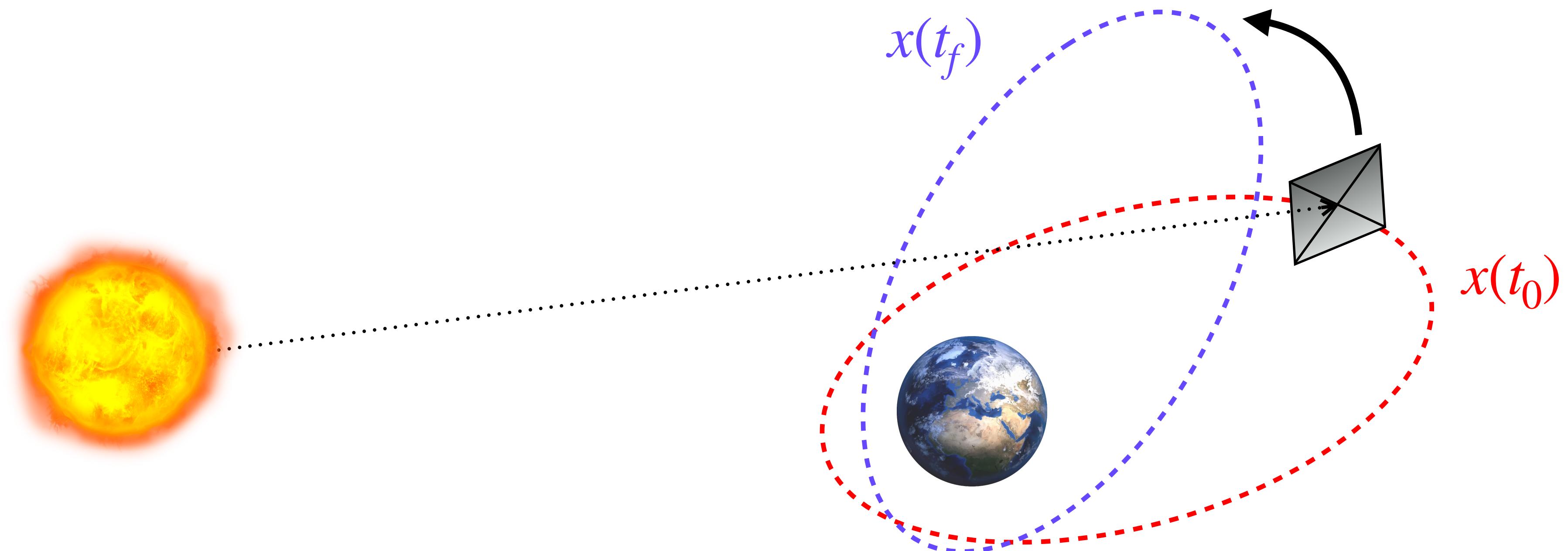
Étude de la contrôlabilité

Théorie du contrôle optimal

Est-ce possible de changer l'orbite avec une voile solaire?



Étude de contrôlabilité permet de calculer les manœuvres possibles



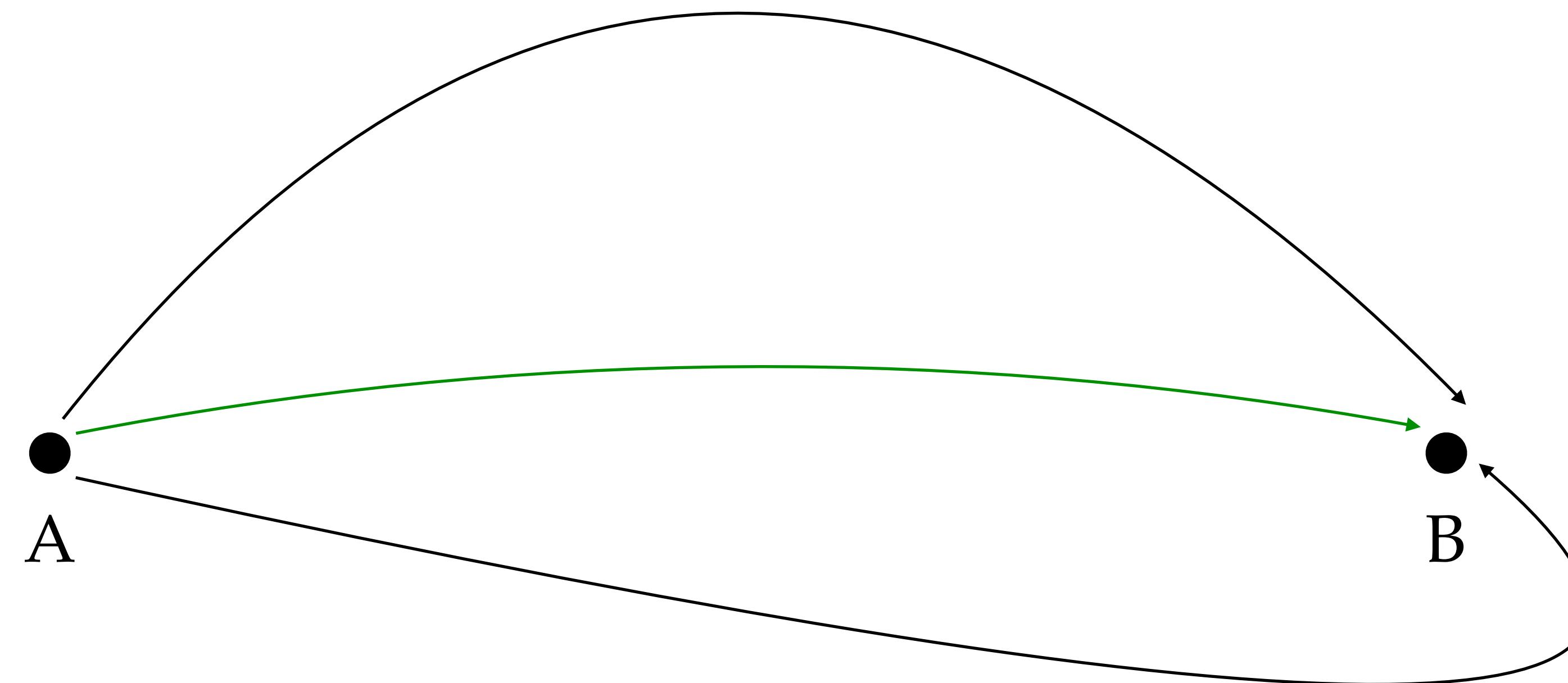
Comment générer $x(t_0) \rightarrow x(t_f)$?

Théorie du contrôle optimal

•
A

•
B

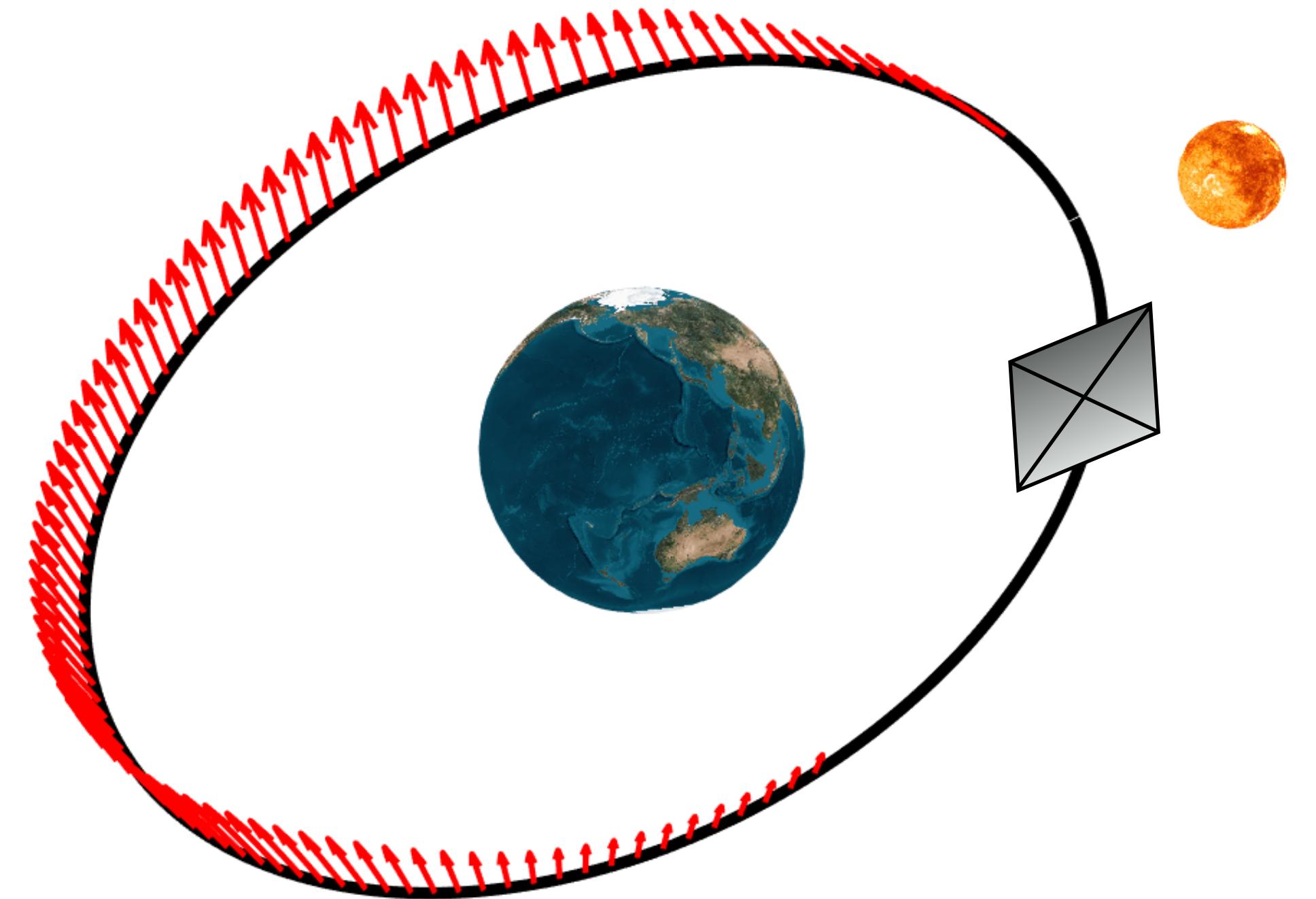
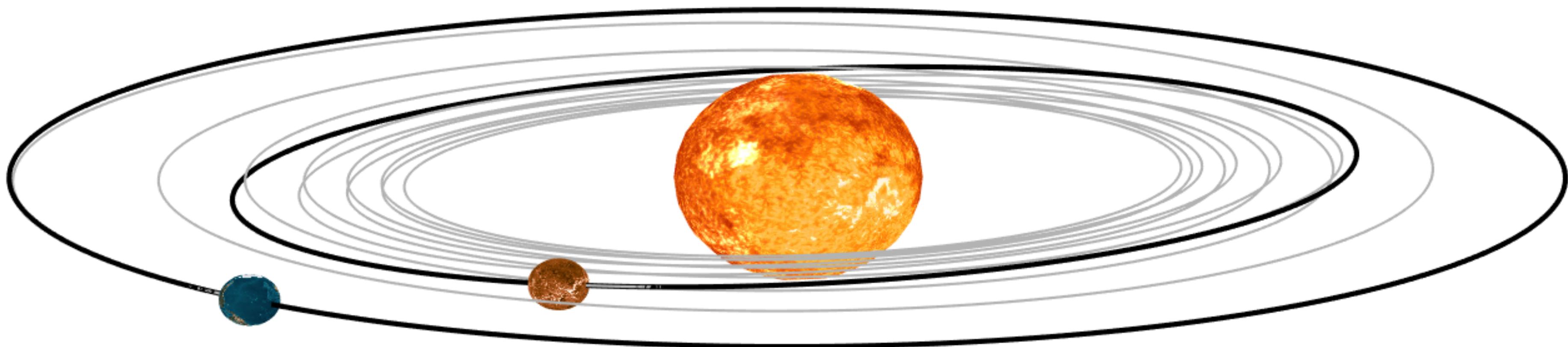
Théorie du contrôle optimal



Théorie du contrôle optimal

1. Poser le problème à résoudre
2. Dériver les conditions mathématiques nécessaires
3. Résoudre le problème avec des logiciels
(Matlab, Python, Julia)

Différentes trajectoires
obtenues grâce à la
théorie du contrôle
optimal

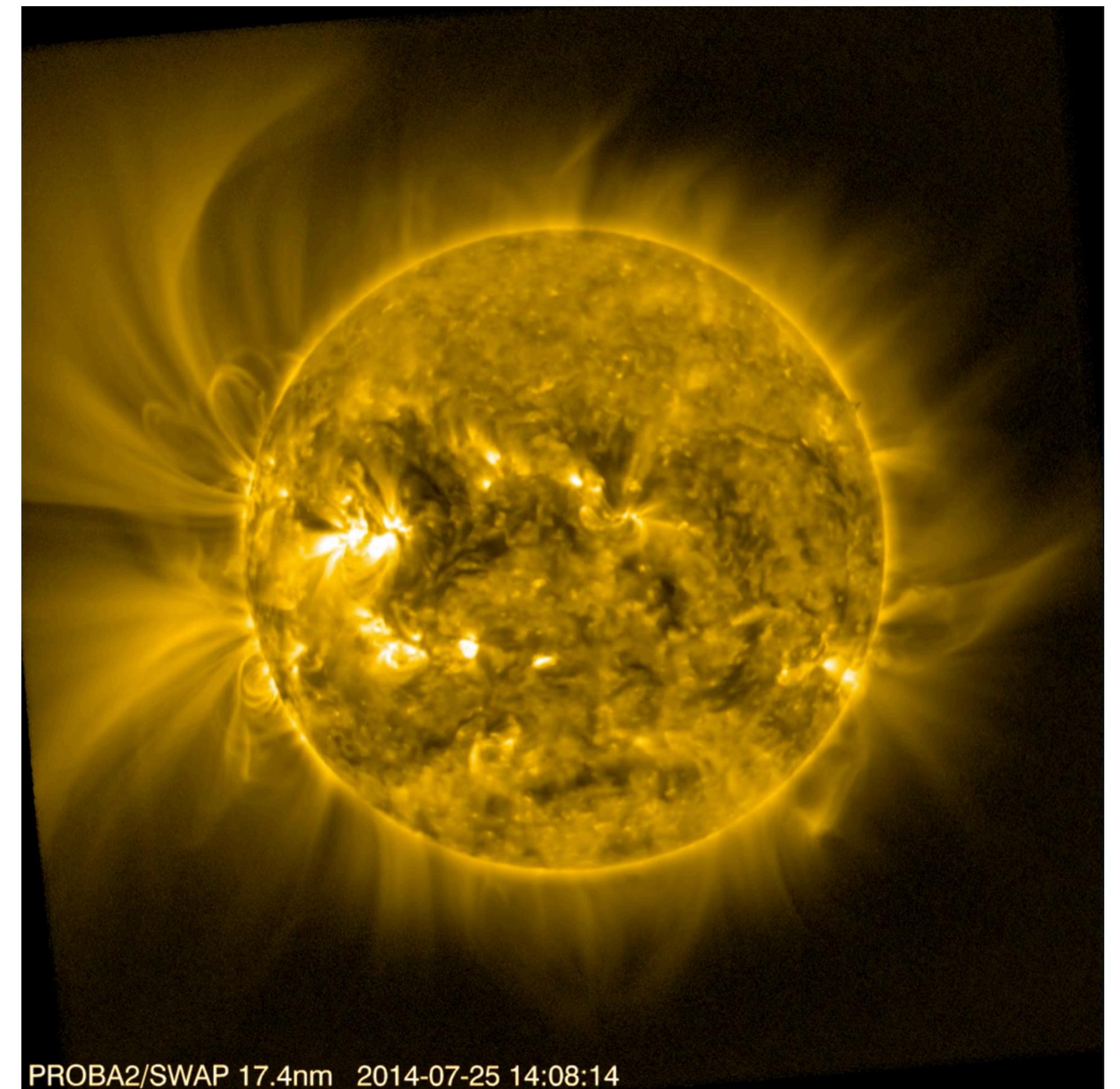


Mission possible grâce à la voile: occultation solaire

Évolution de la couronne solaire

Impact important sur la “météo spatiale”

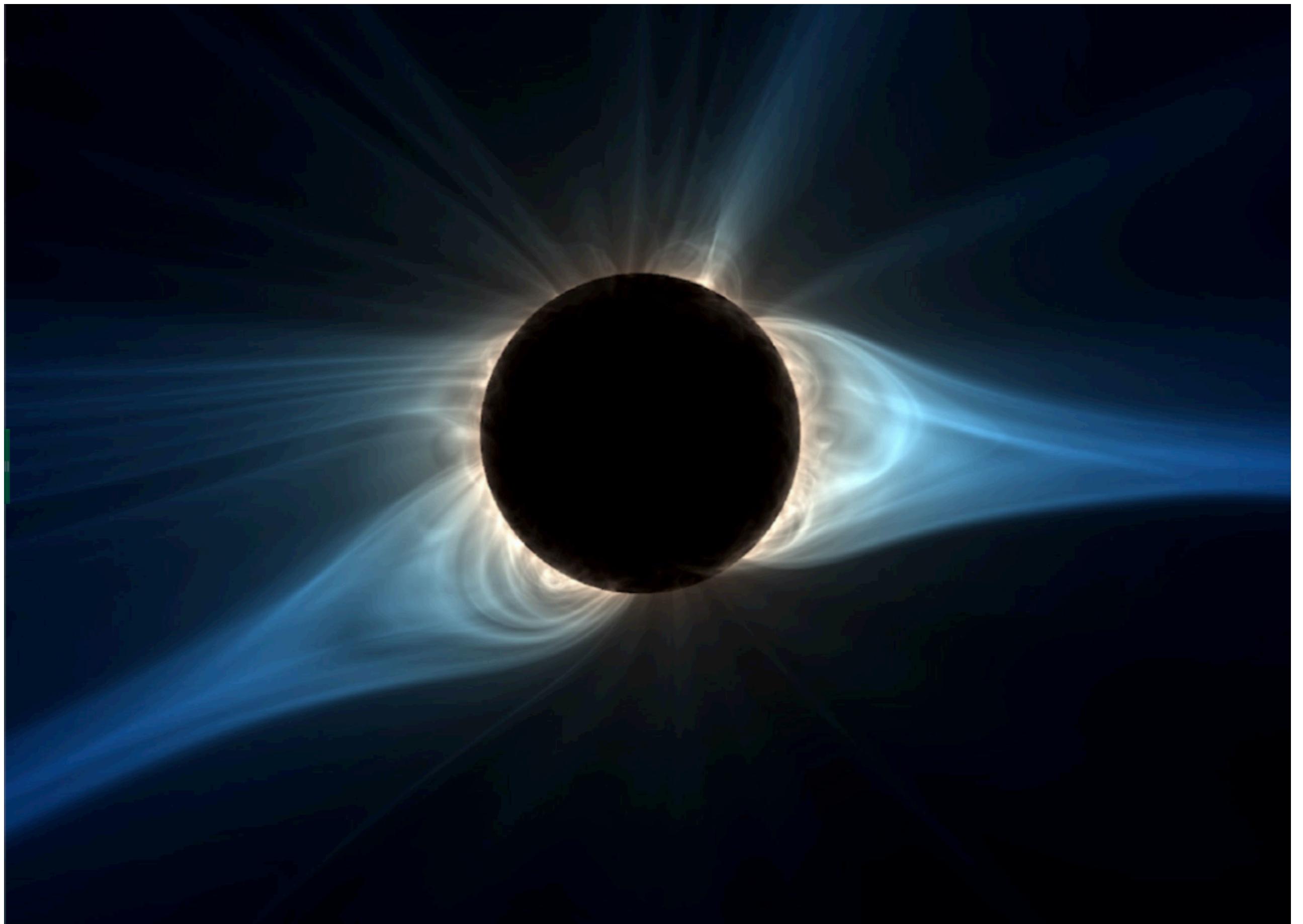
et les missions spatiales



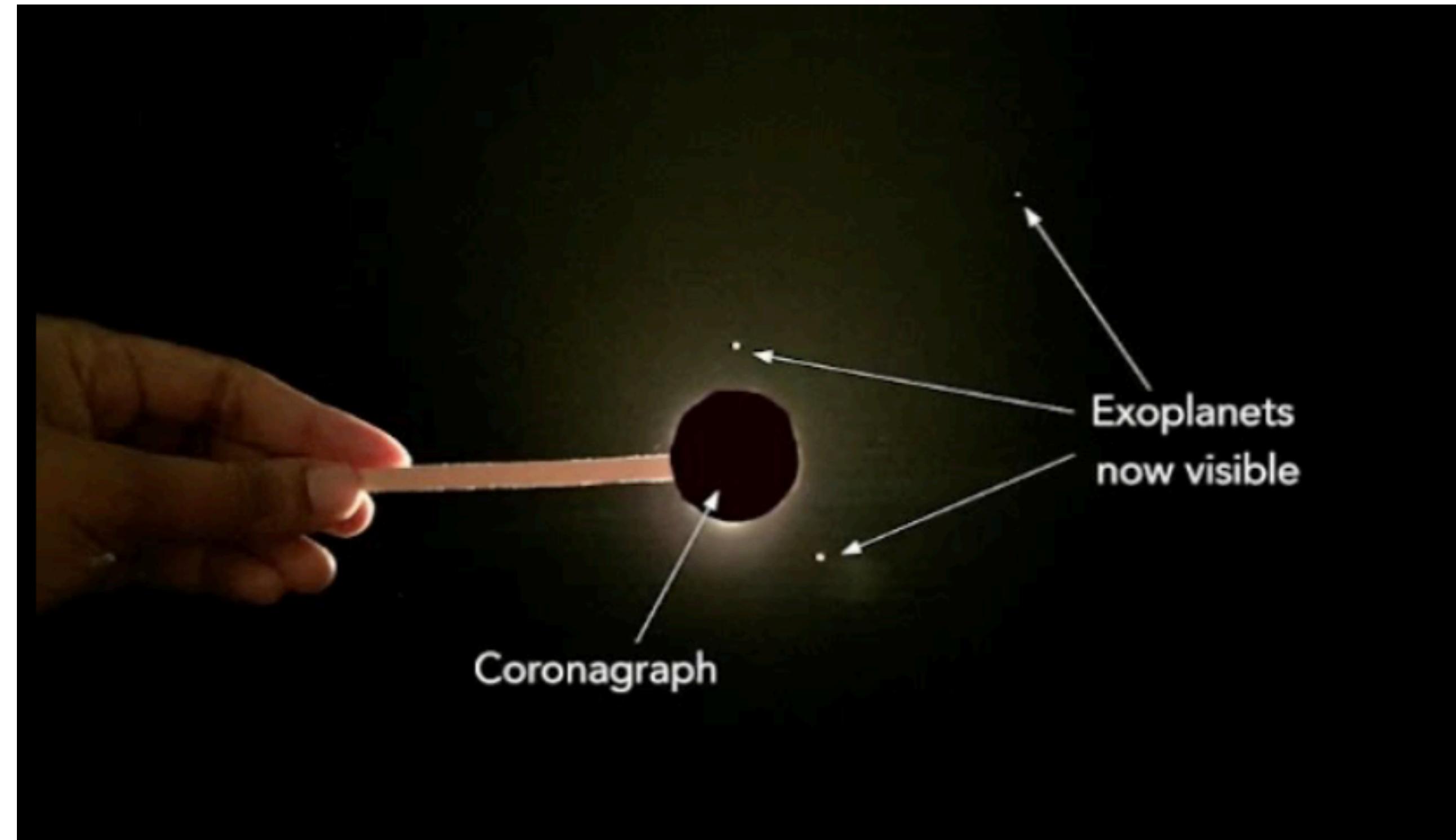
Comment observer la couronne solaire?

Depuis la terre durant les éclipses
(chaque 18 mois)

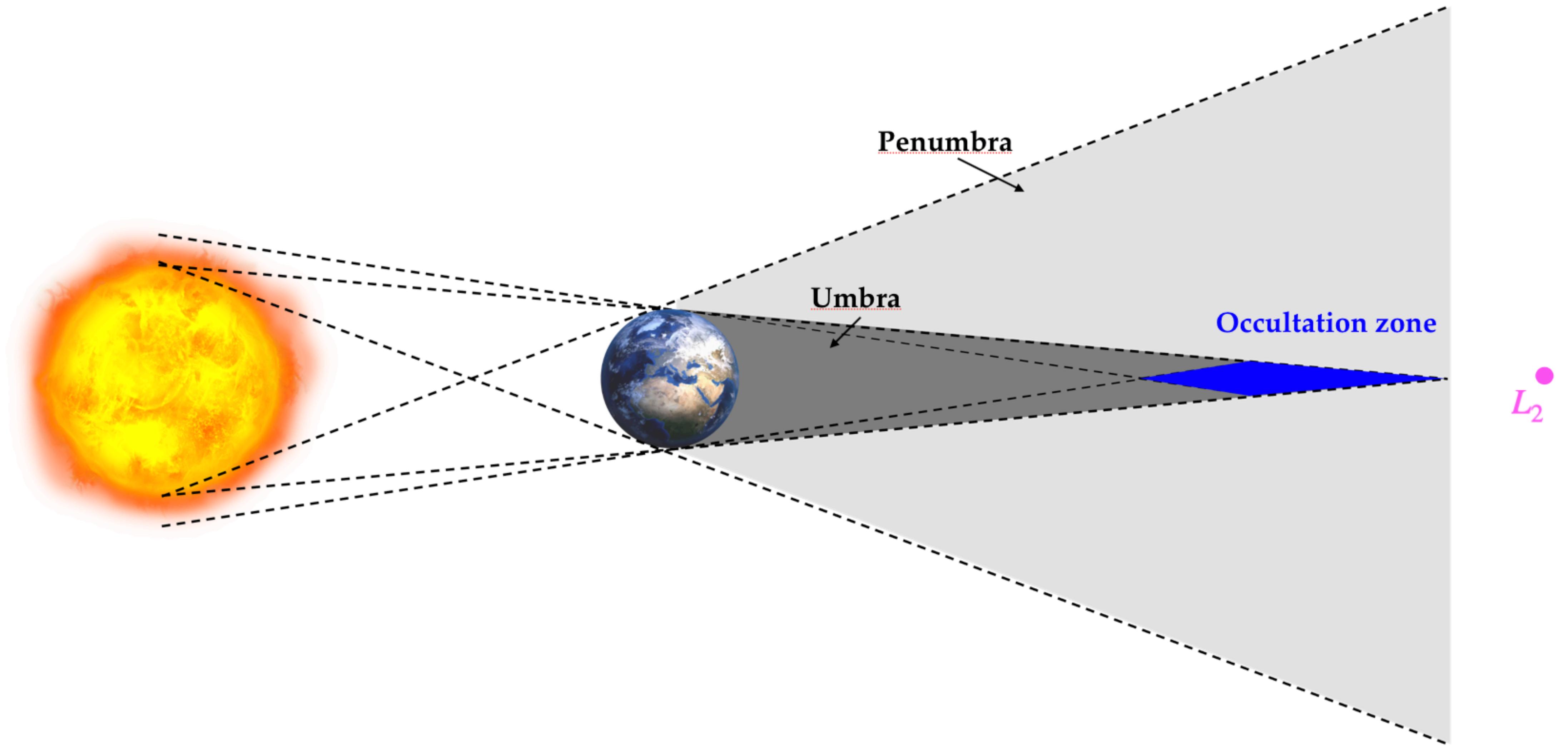
Depuis l'espace:
ESA PROBA - 3



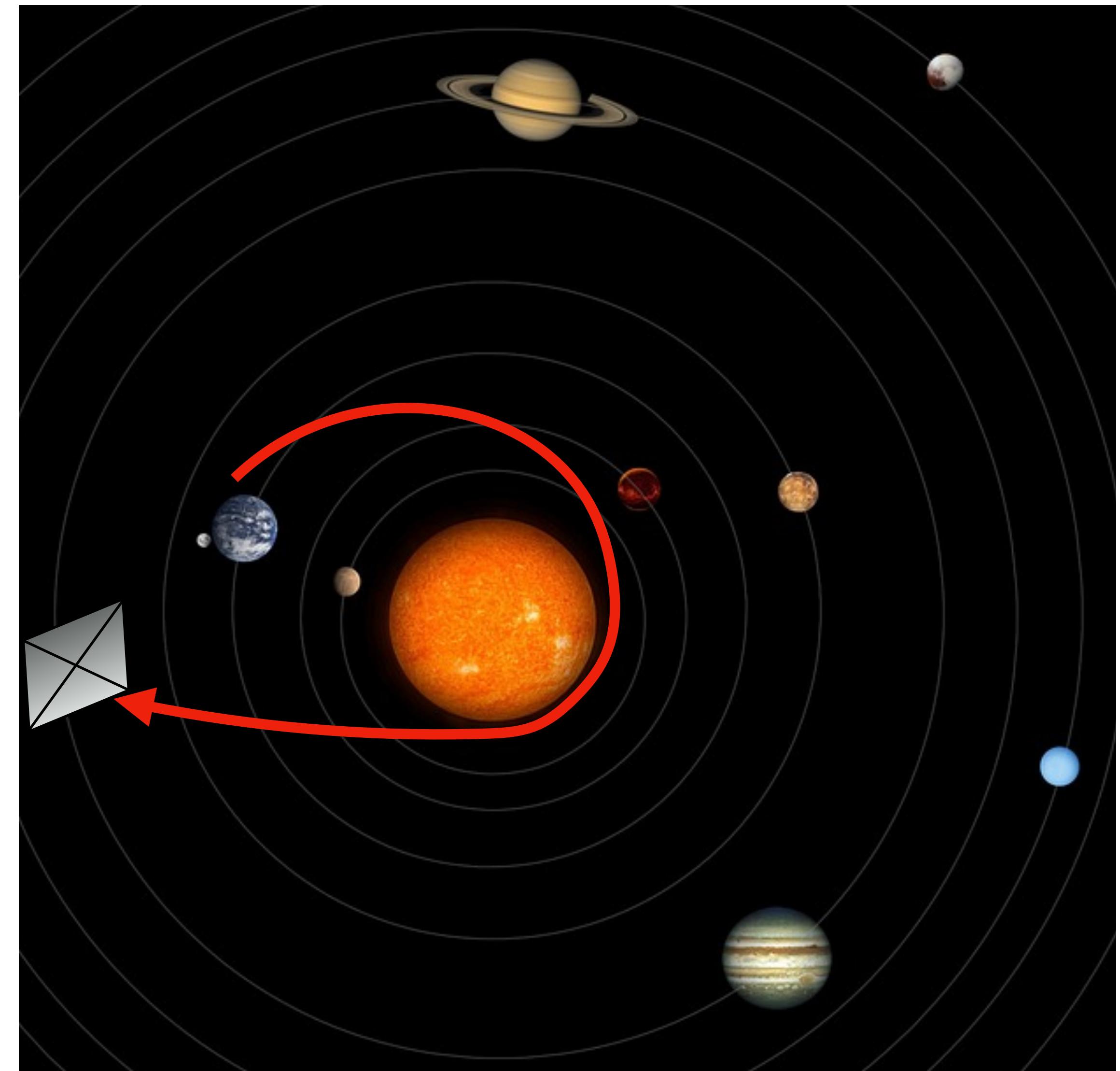
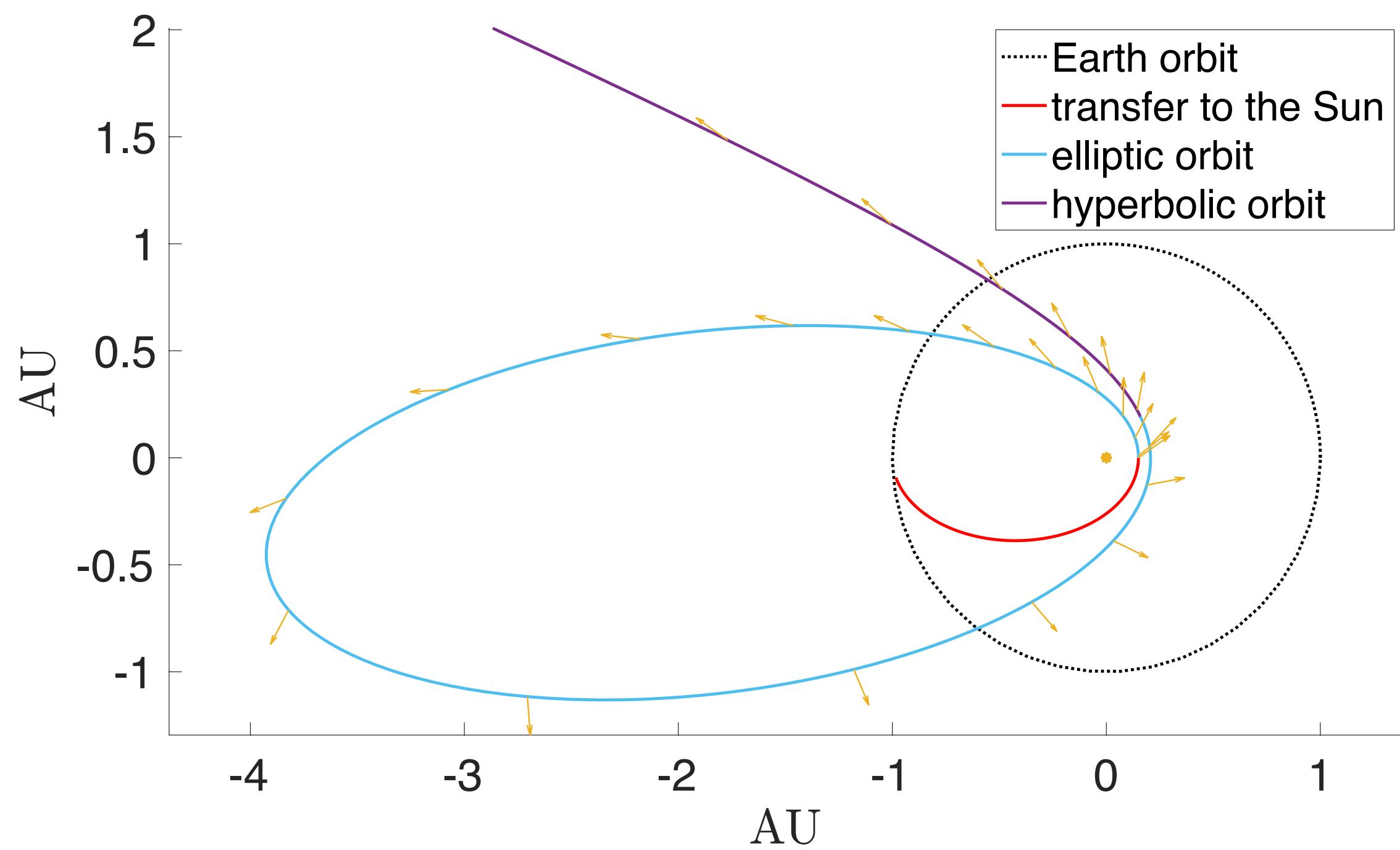
On peut utiliser les coronographies



Utiliser la Terre en tant qu'occultant

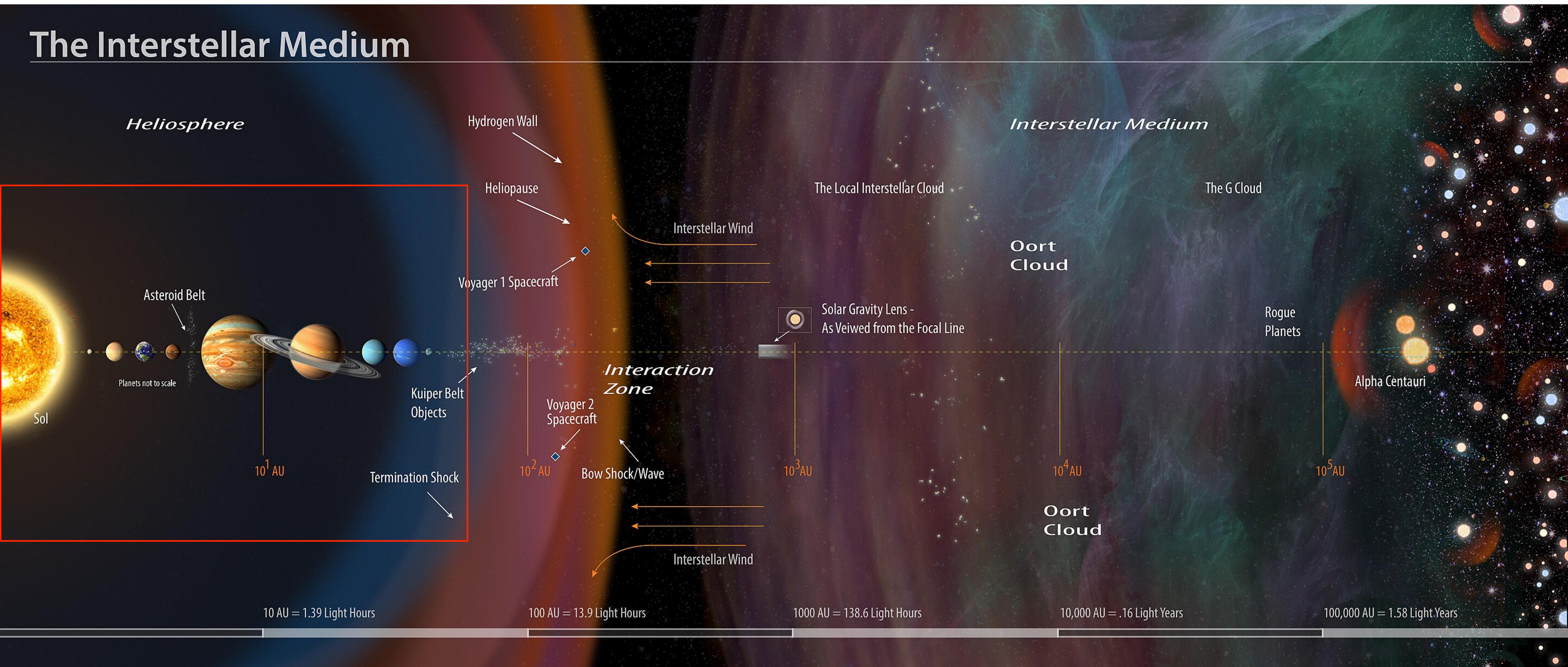


À l'infini et au-delà

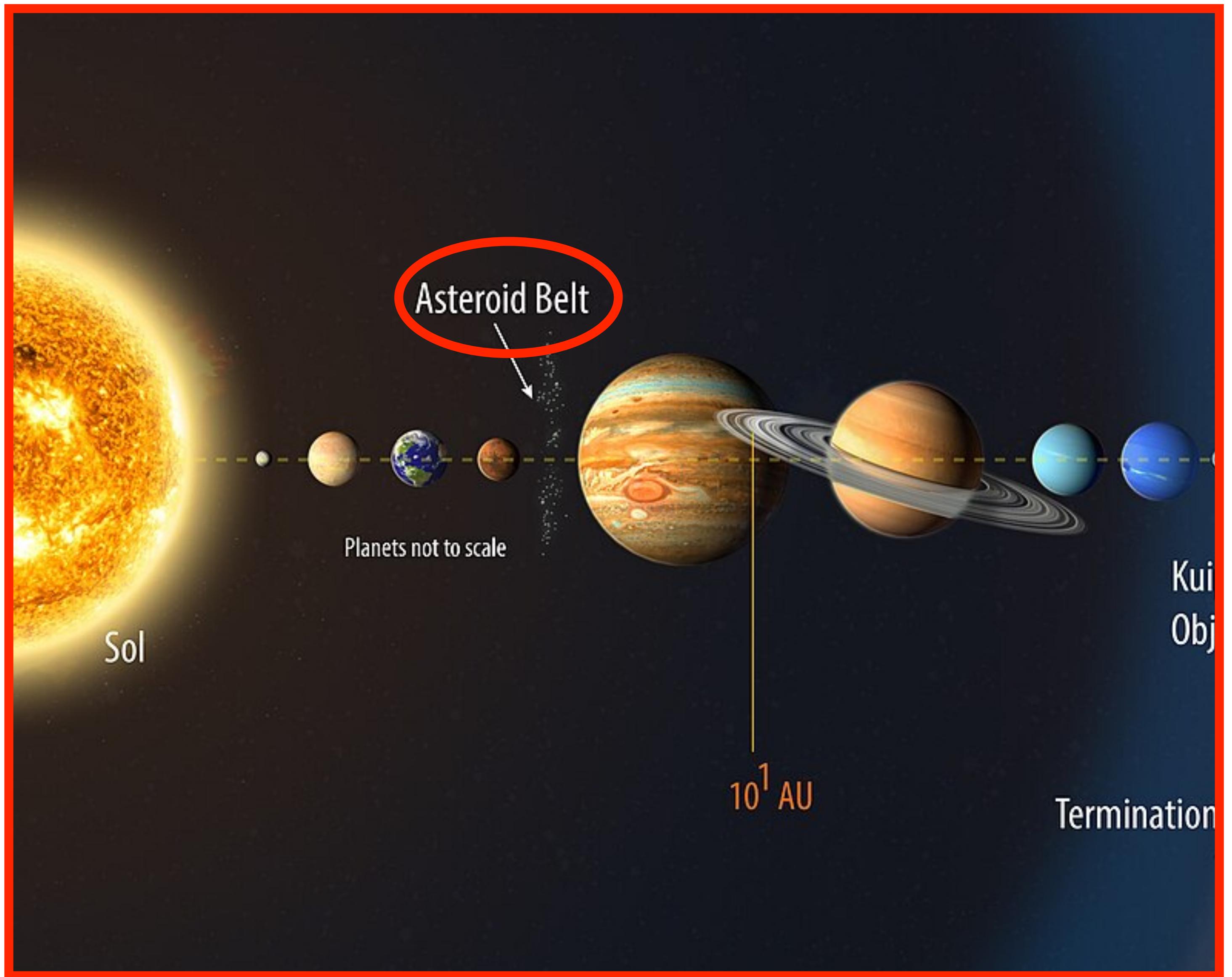


Mon travail actuel

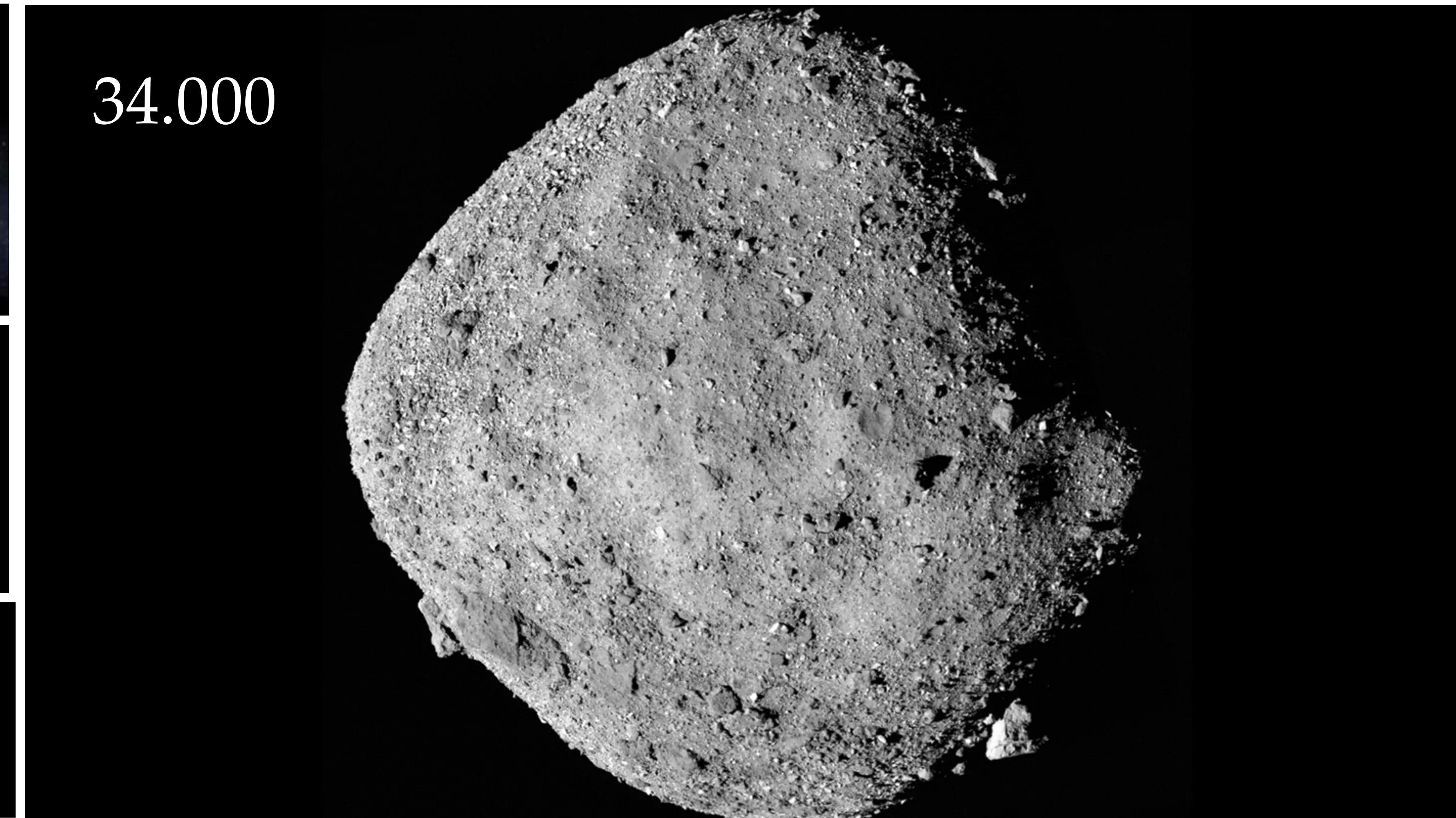
The Interstellar Medium



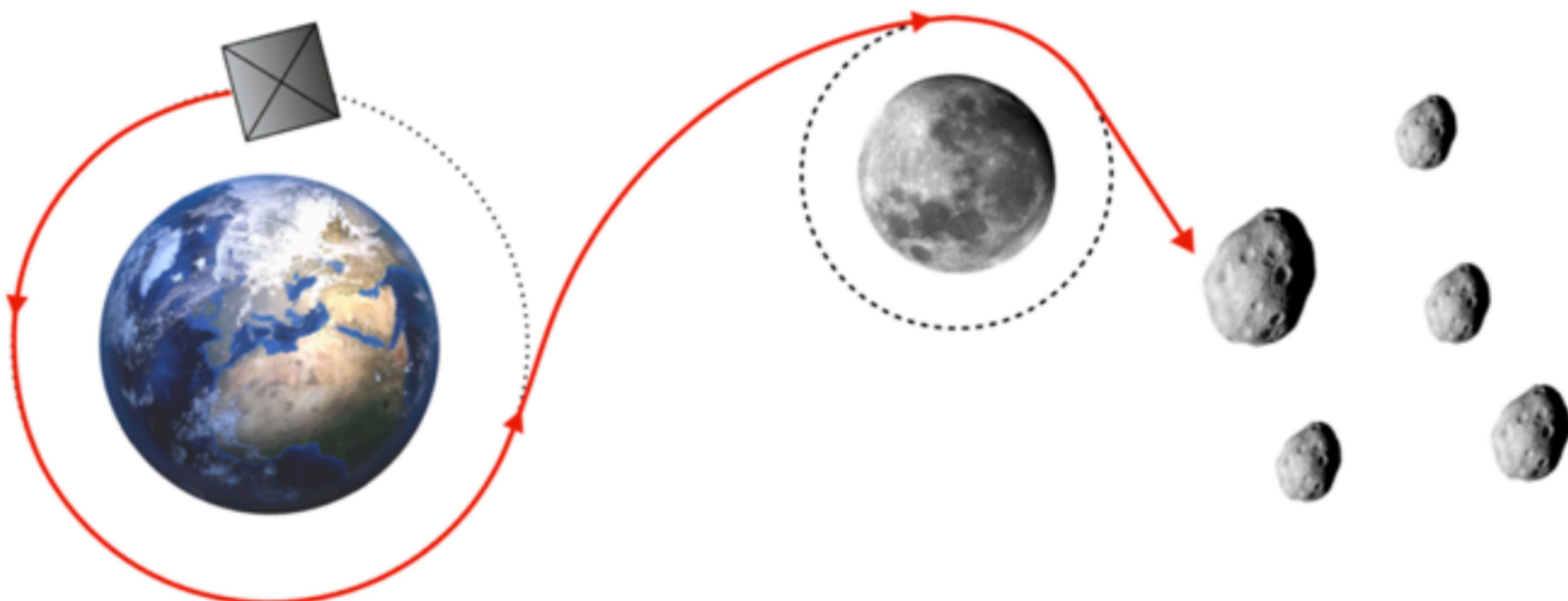
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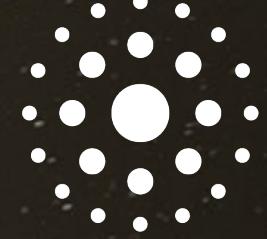


Mon travail actuel



Mon travail actuel





Vers l'infini et au-delà... à la voile

Alesia Herasimenka

