

# Da exploração do sistema solar aos videojogos

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Escola de Verão de Física

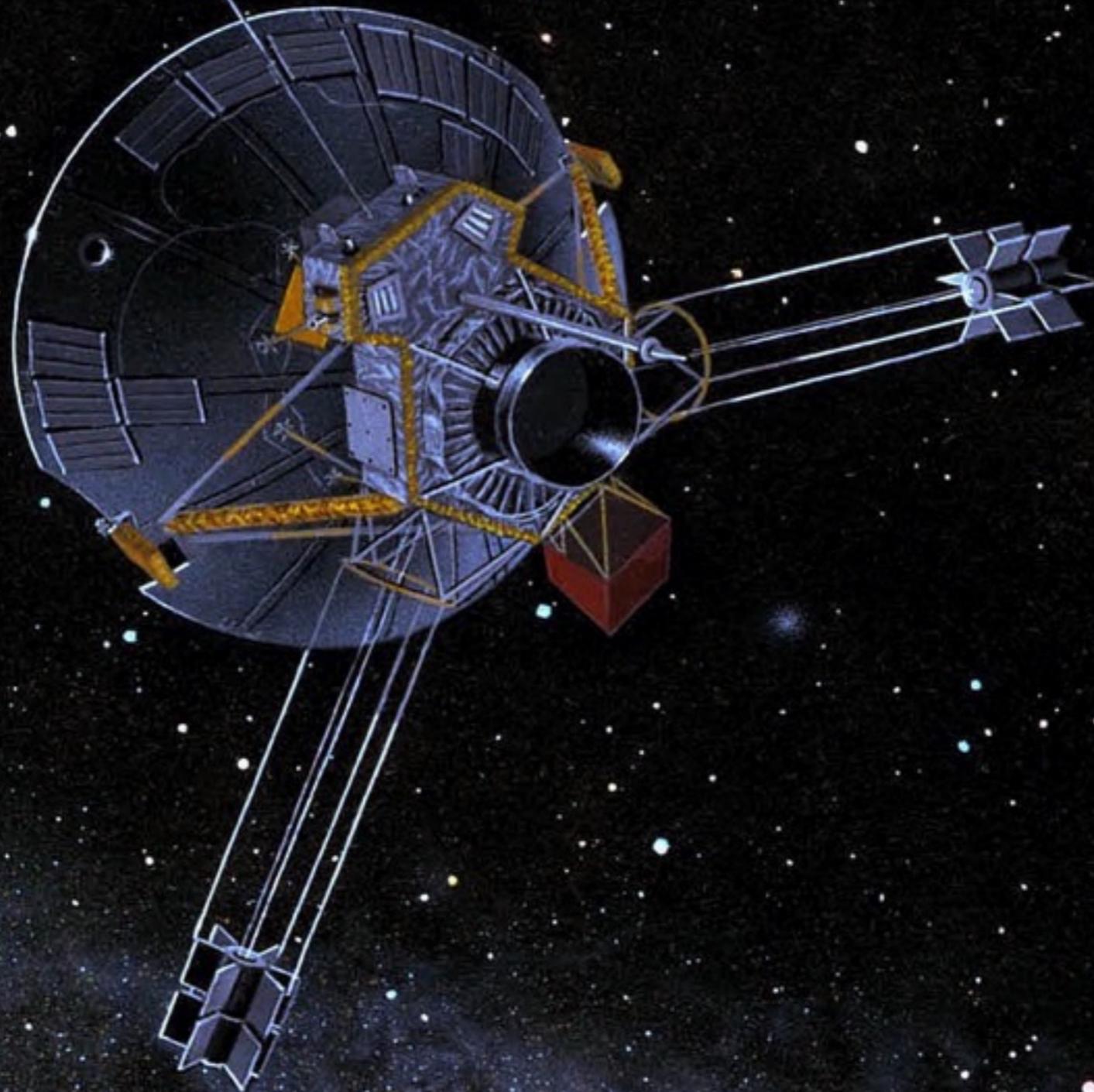
Faculdade de Ciências da Universidade do Porto

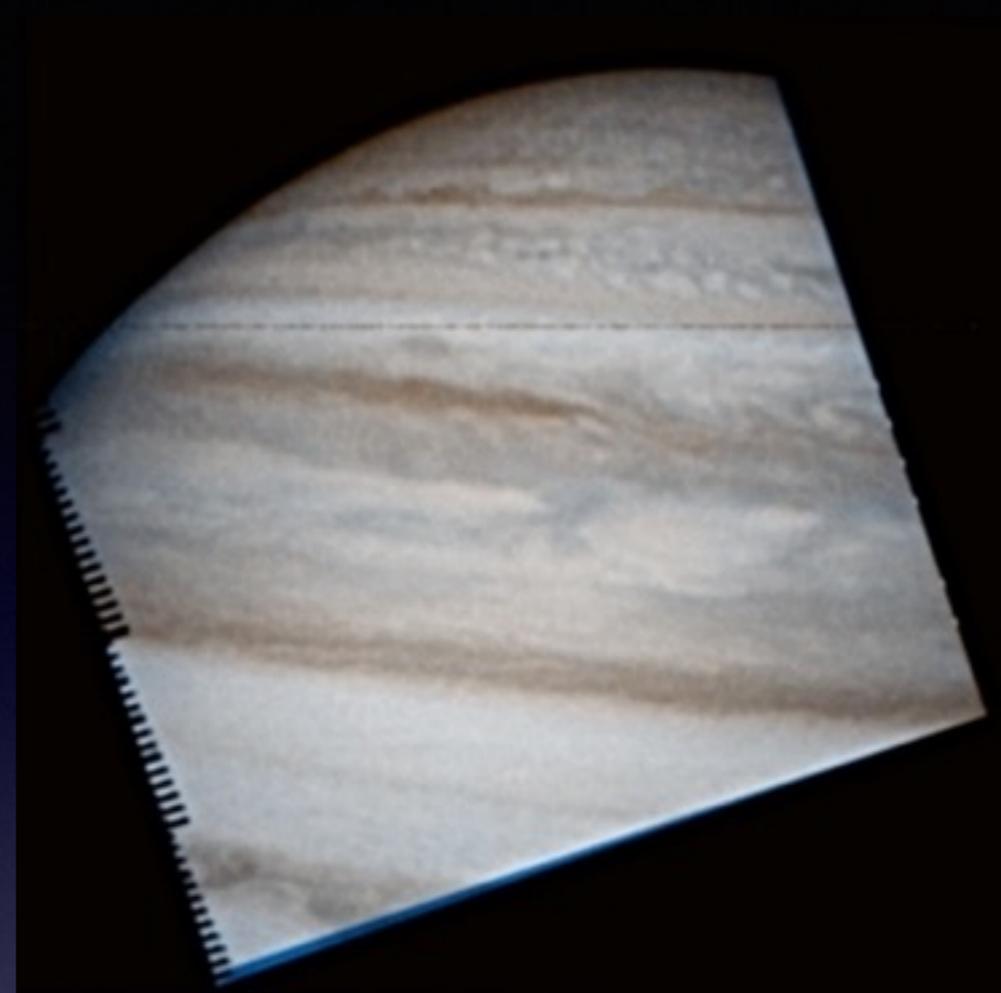
# A Exploração do Sistema Solar

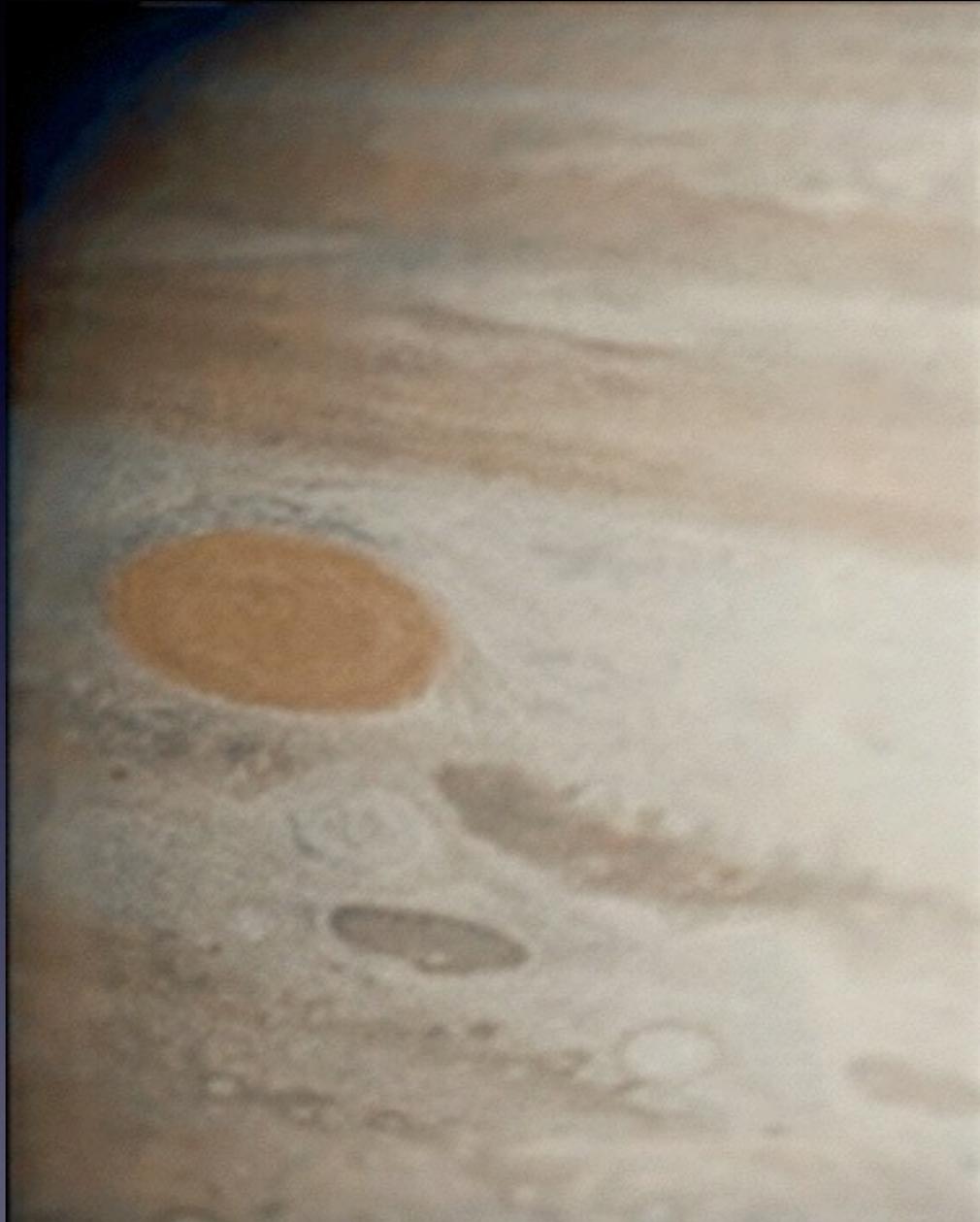
# Distâncias

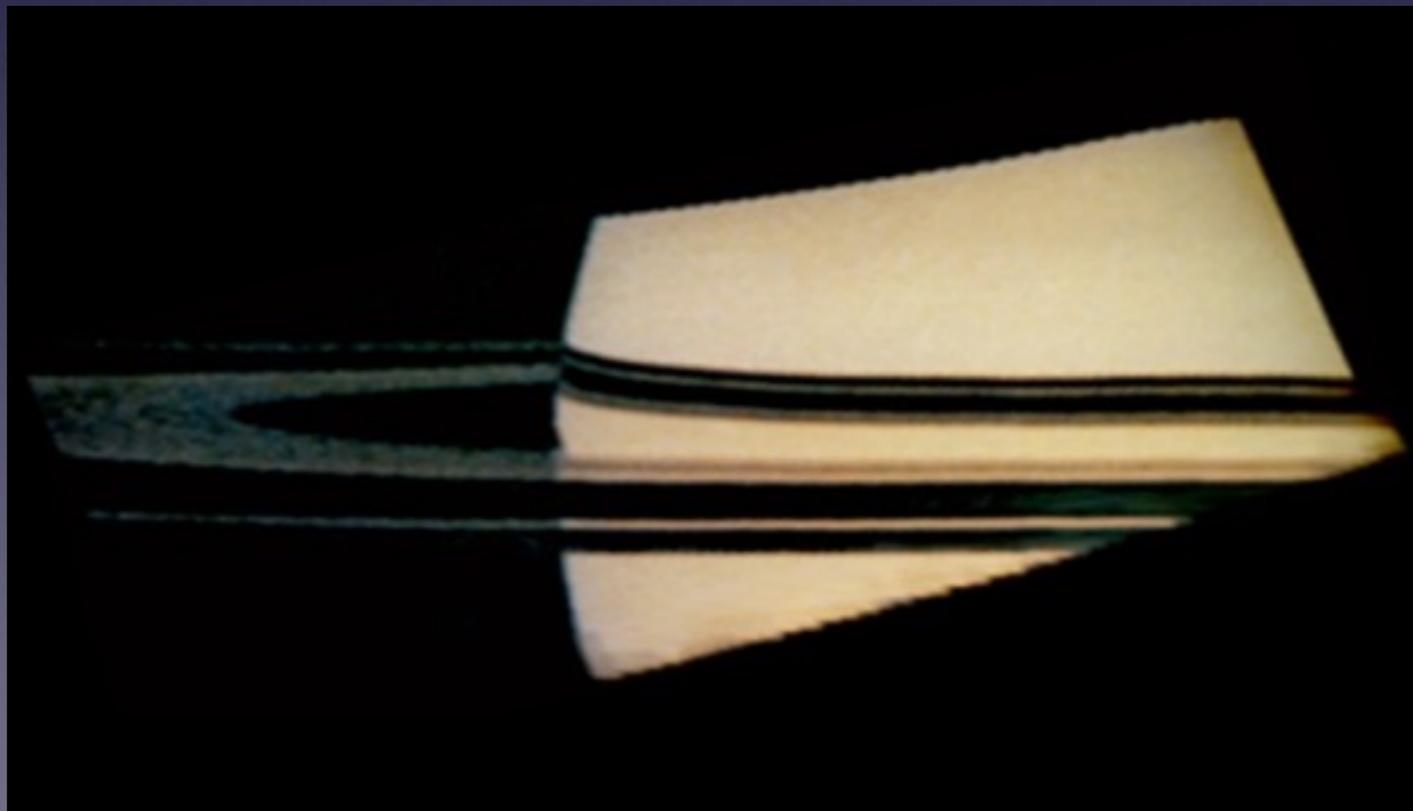
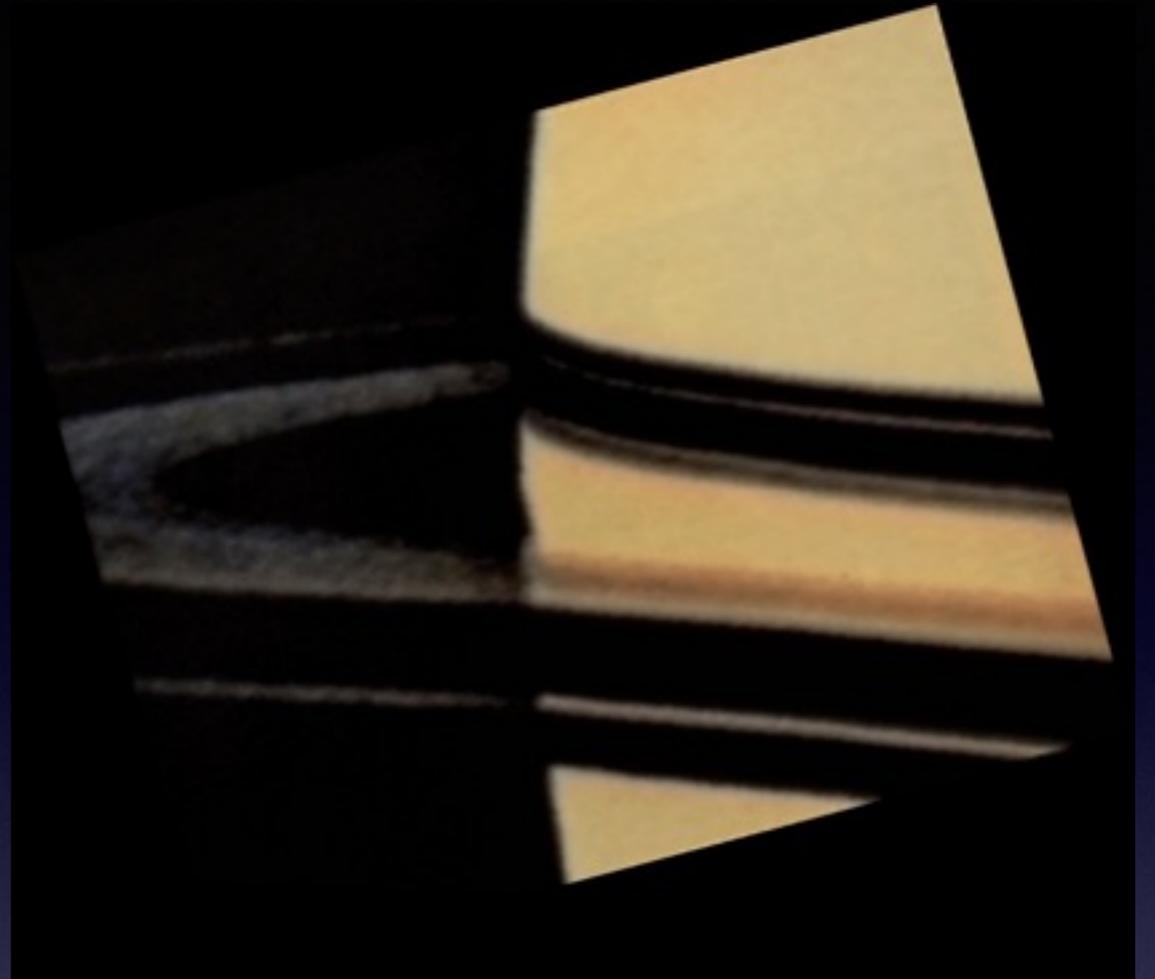
- Limiar do espaço: 100 km
- Órbita Baixa: 160 a 2000 km
- Terra - Lua: 380 000 km
- Sol - Terra: 150 000 000 km
- Sol - Saturno: 1 400 000 000 km

# Pioneer 10 & 11





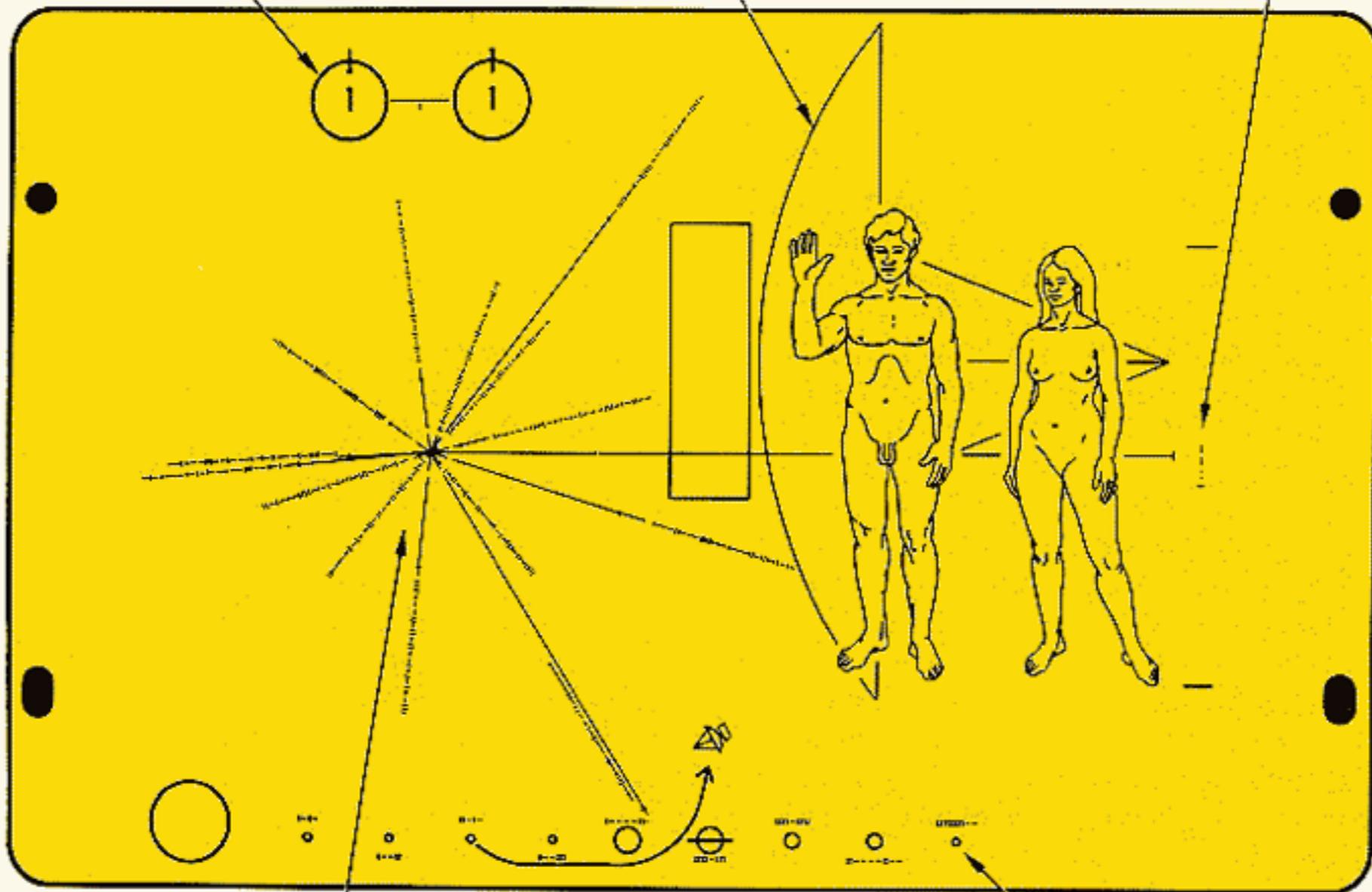




HYPERFINE TRANSITION OF  
NEUTRAL HYDROGEN

SILHOUETTE OF  
SPACECRAFT

BINARY EQUIVALENT  
OF DECIMAL 8

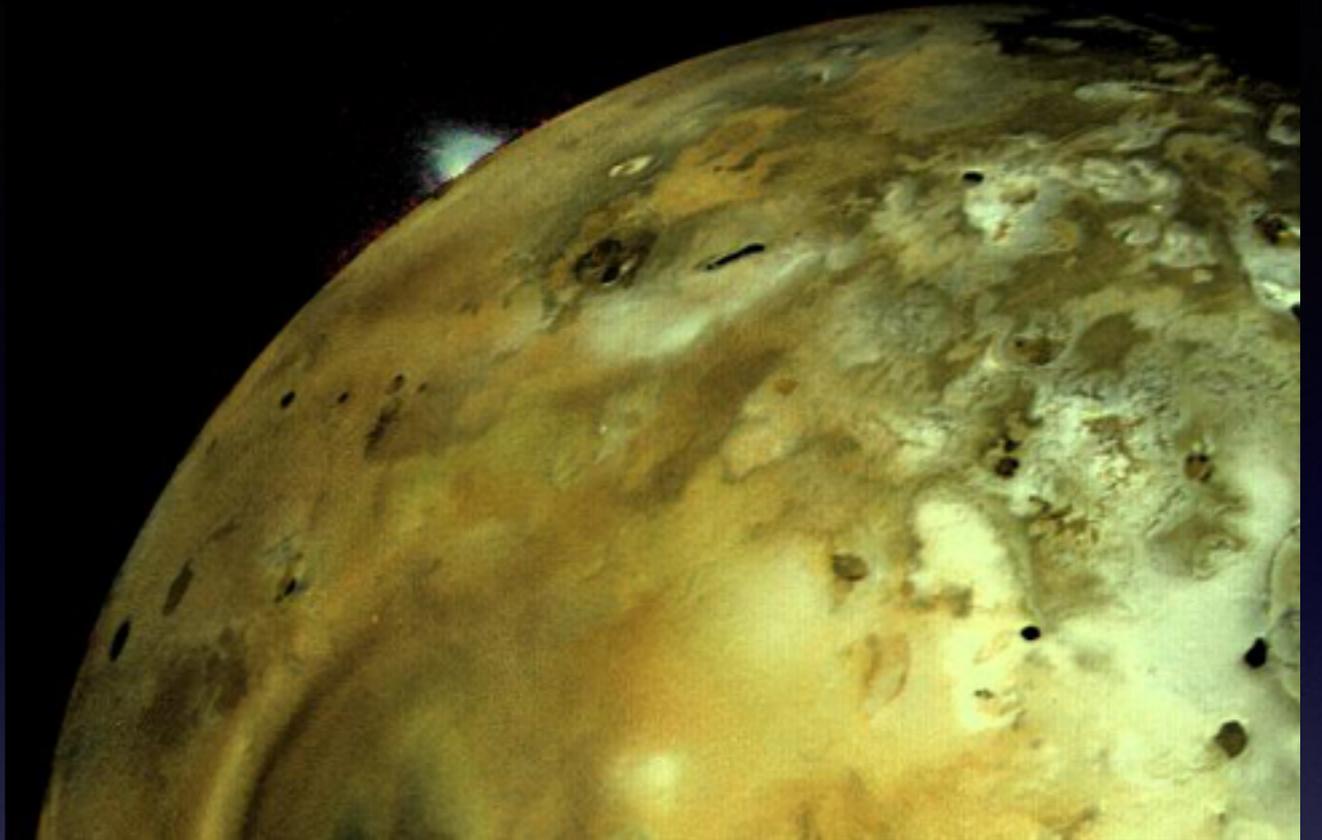


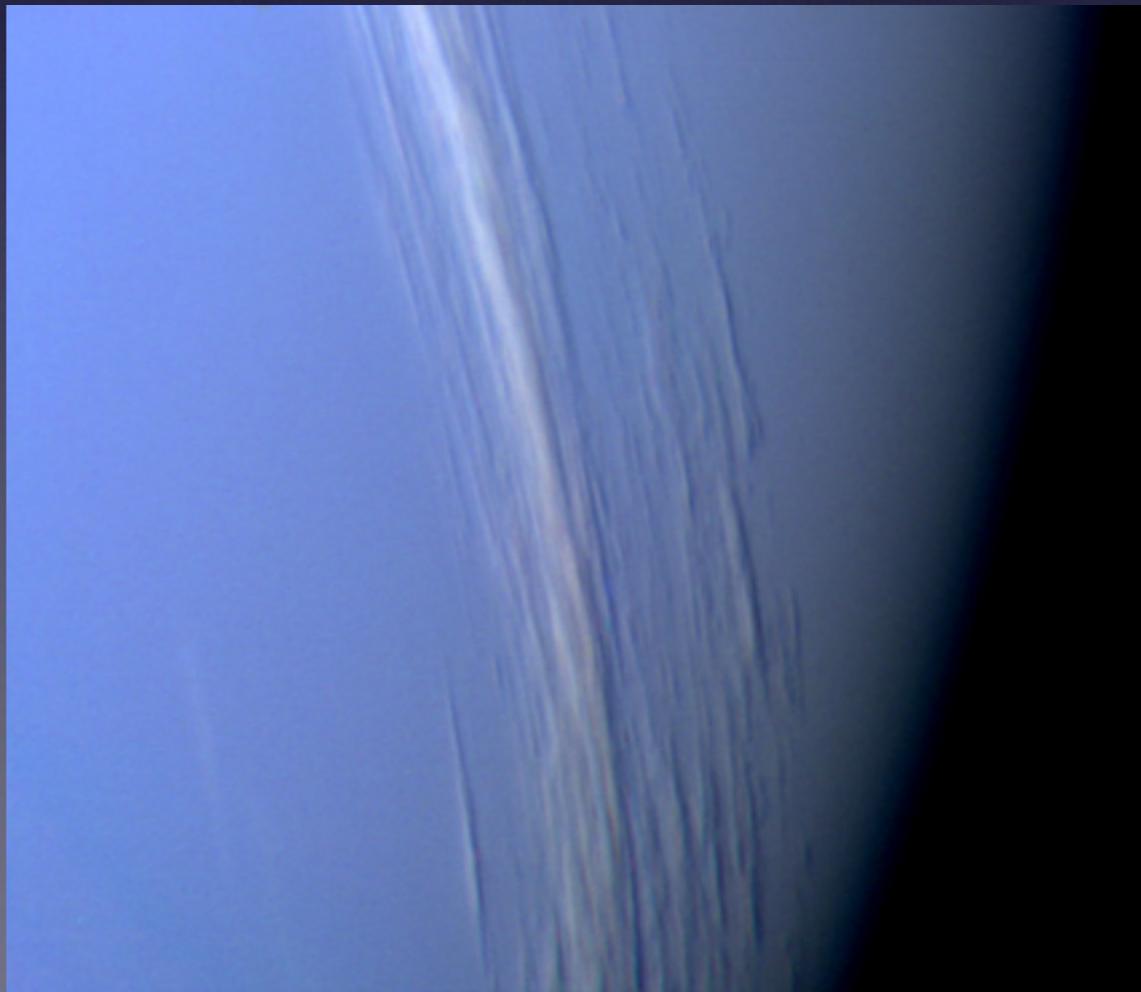
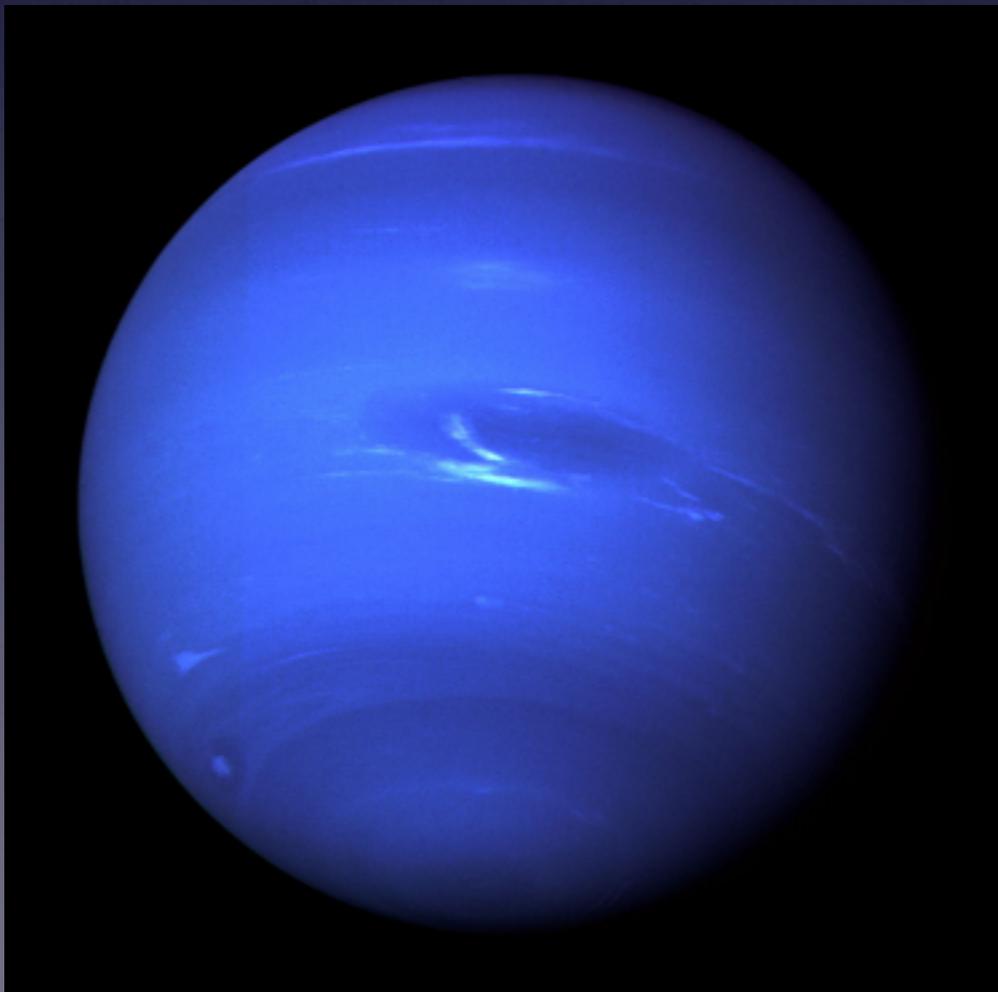
POSITION OF SUN  
RELATIVE TO 14  
PULSARS AND THE  
CENTER OF THE GALAXY

PLANETS OF SOLAR  
SYSTEM AND BINARY  
RELATIVE DISTANCES

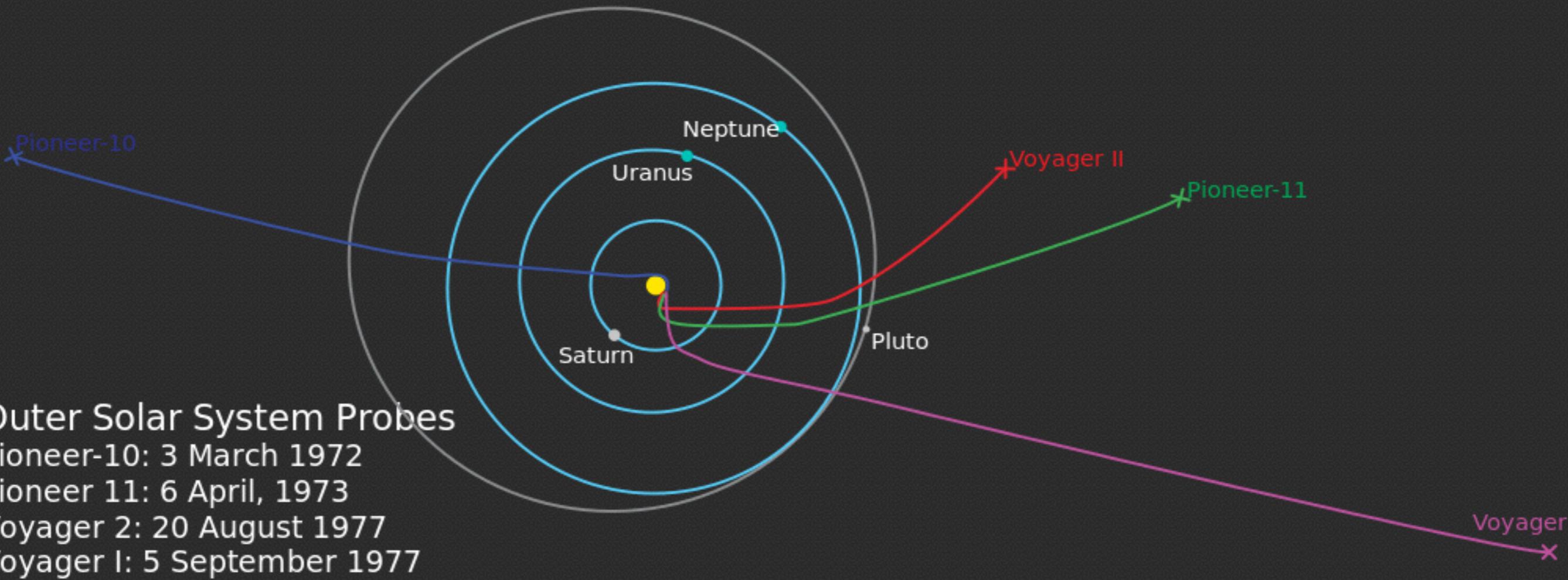
# Voyager 1 & 2











# Cassini



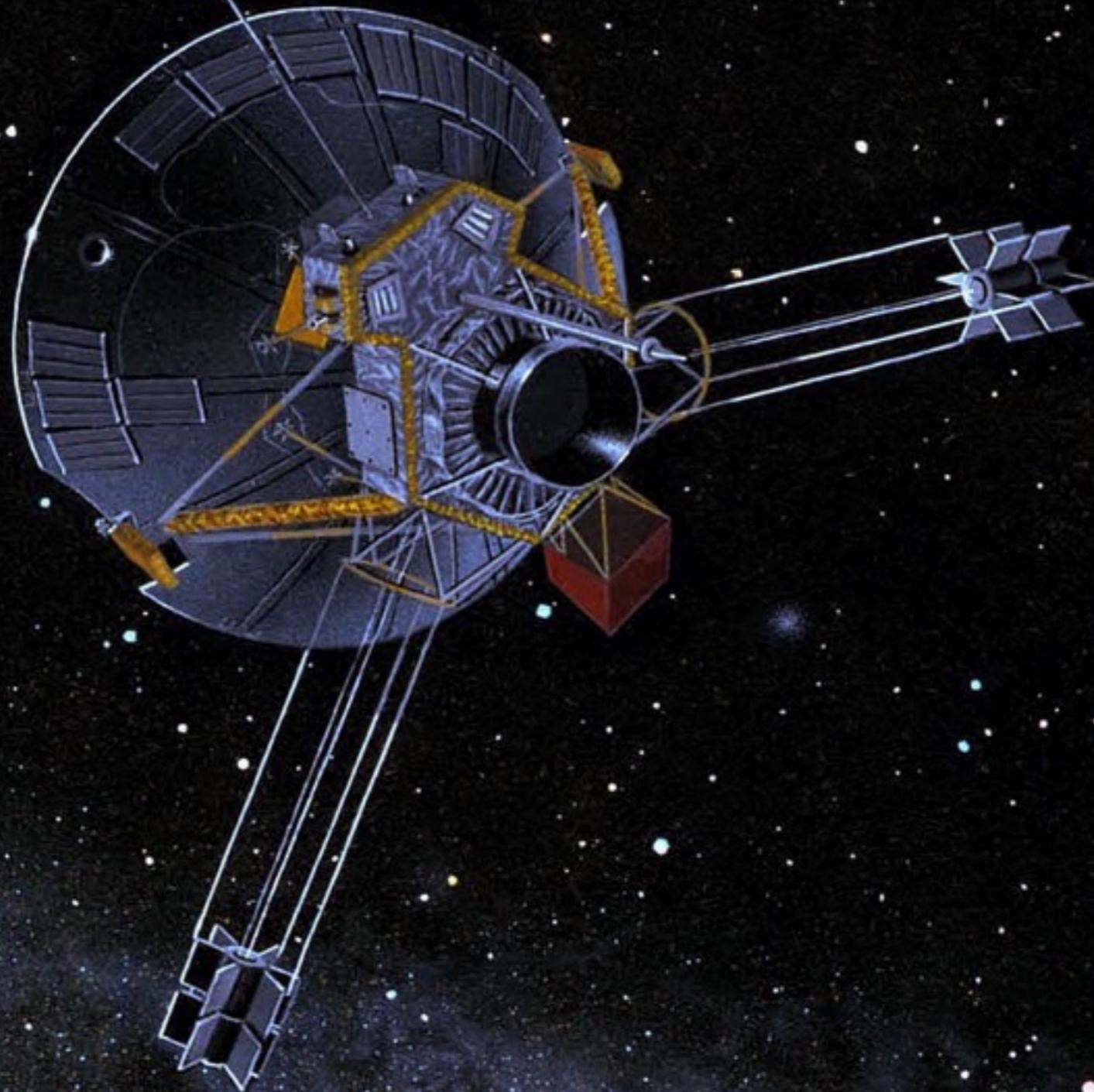


# New Horizons





# Pioneer 10 & 11



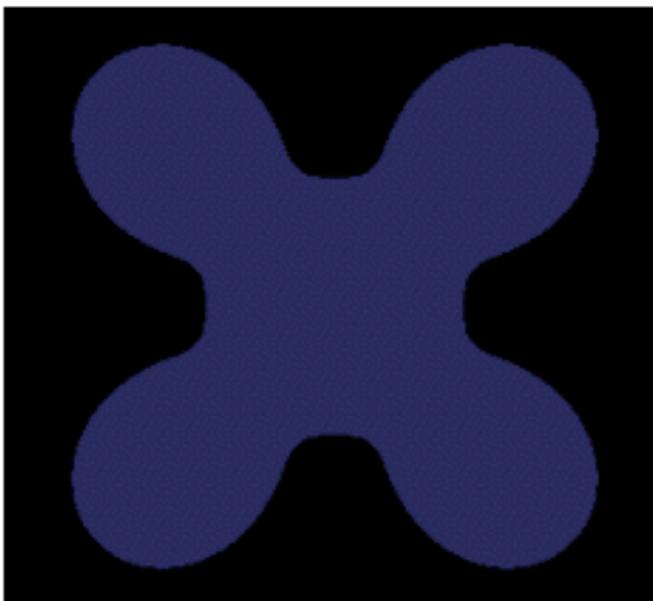
# A Anomalia das Pioneer

Explicações?

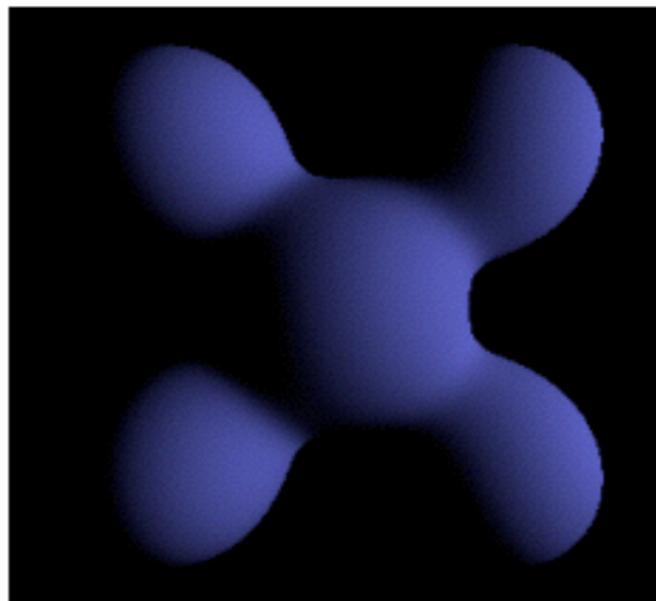


# Modelo de Reflexão de Phong

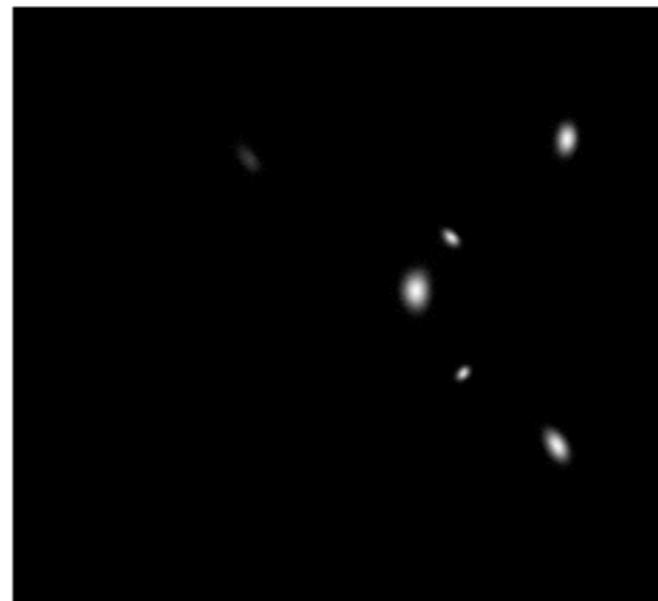
$$I_p = k_a i_a + \sum_{m \in \text{lights}} [k_d (\mathbf{l}_m \cdot \mathbf{n}) i_d + k_s (\mathbf{r}_m \cdot \mathbf{v})^\alpha i_s]$$



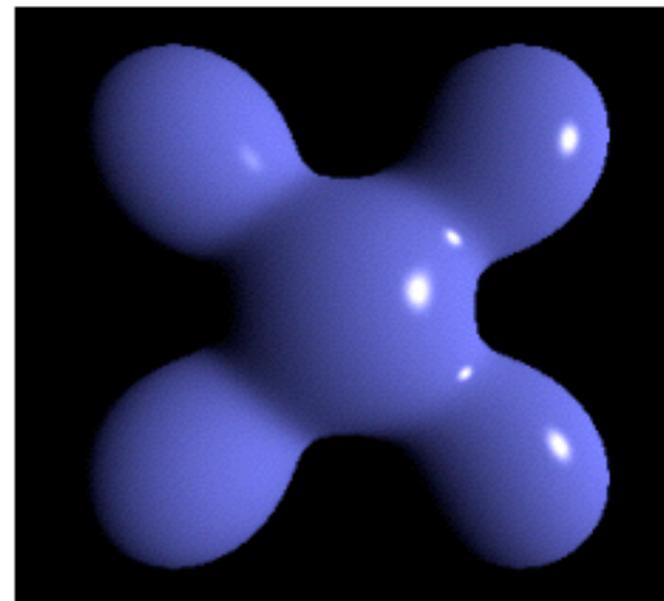
**Ambient**



**Diffuse**



**Specular**



**= Phong Reflection**

+

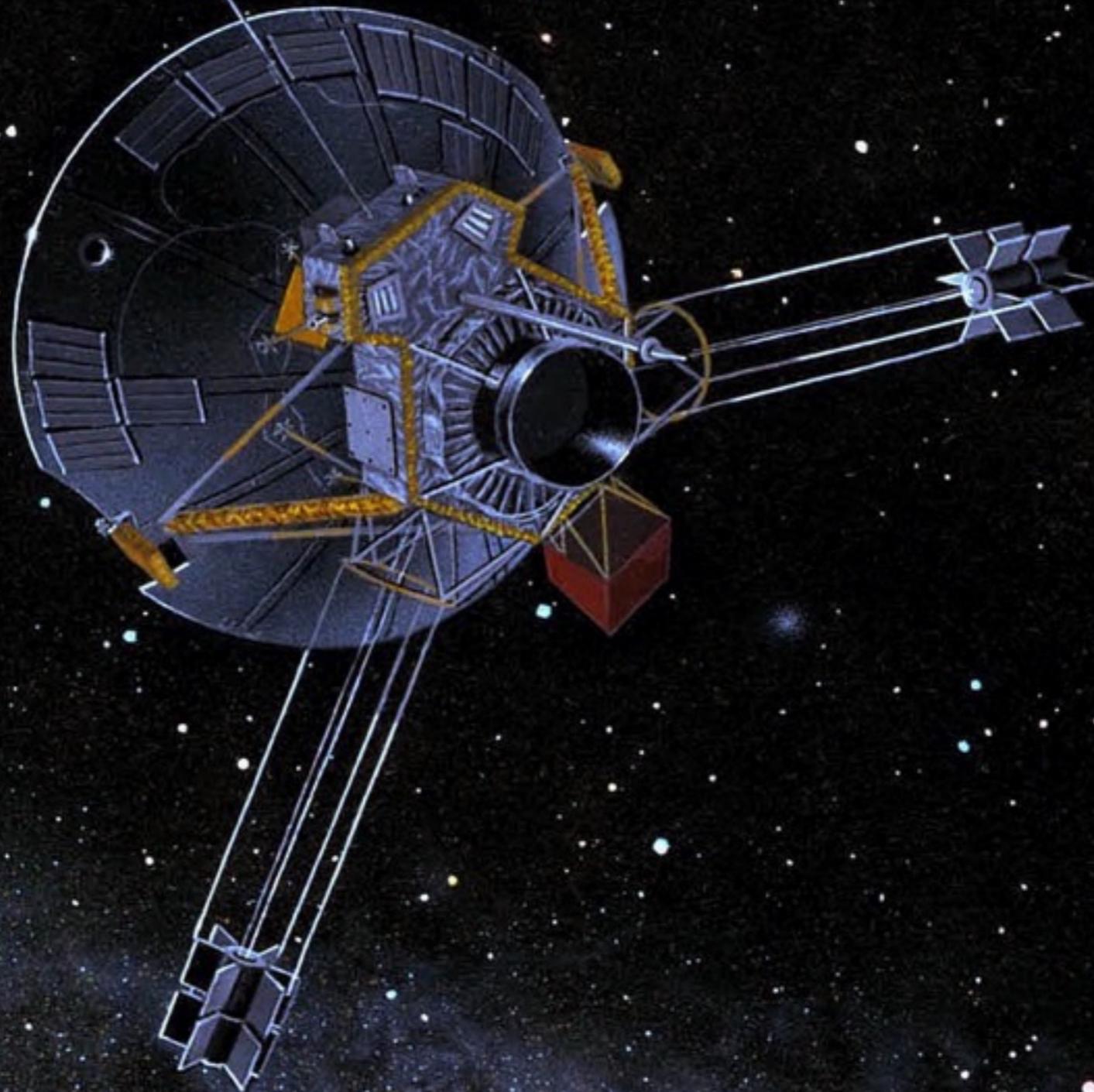
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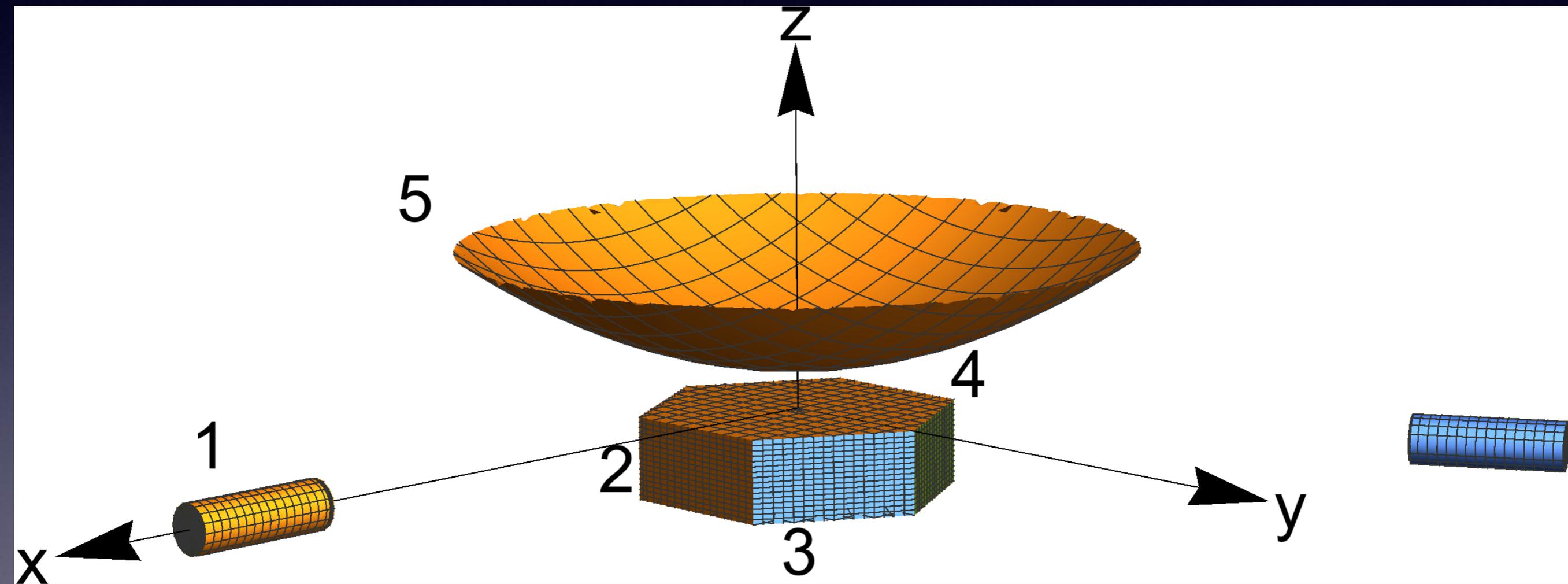


**BMW M3 Coupé**

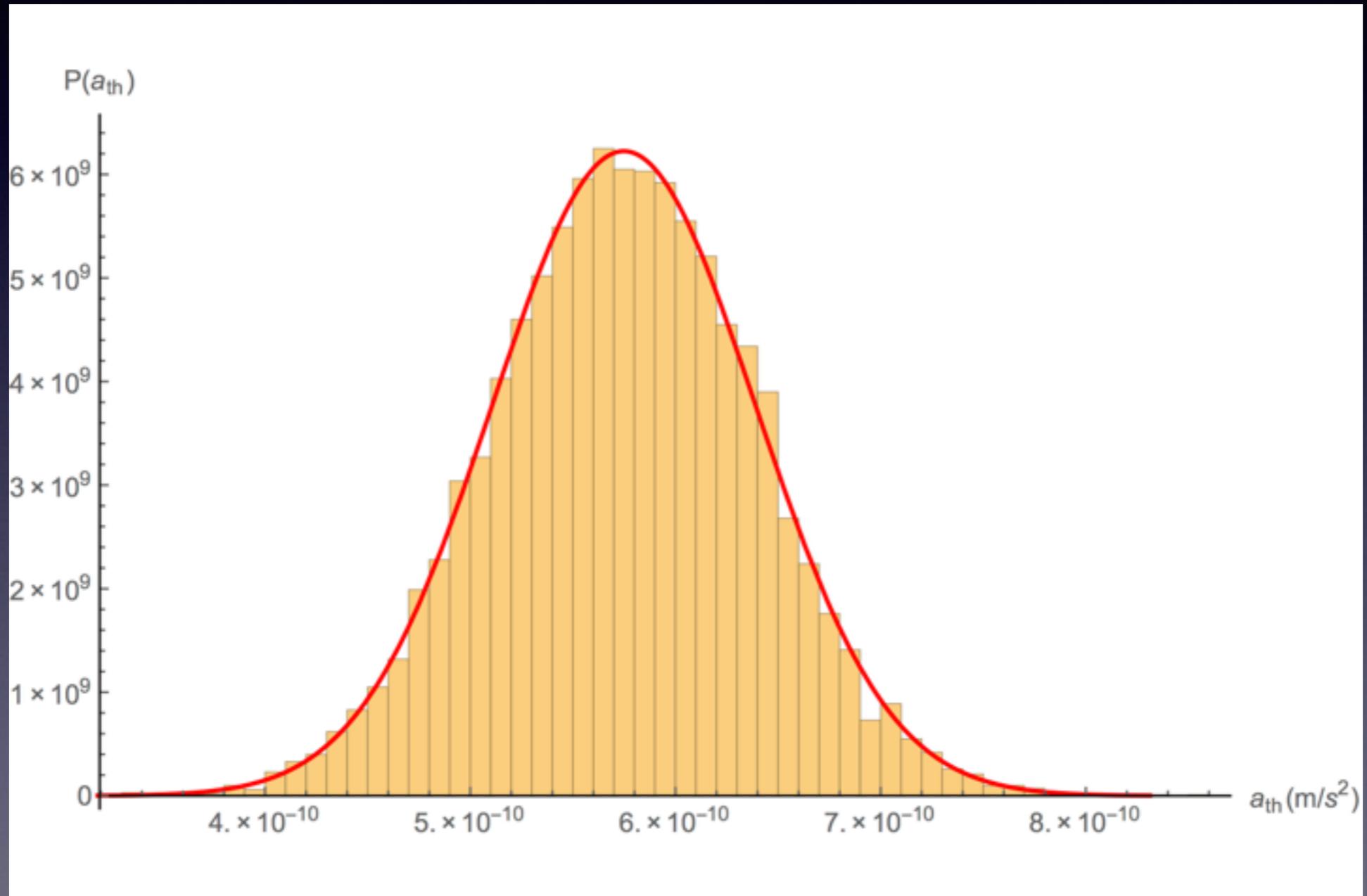
# A Anomalia das Pioneer



# Modelo Matemático

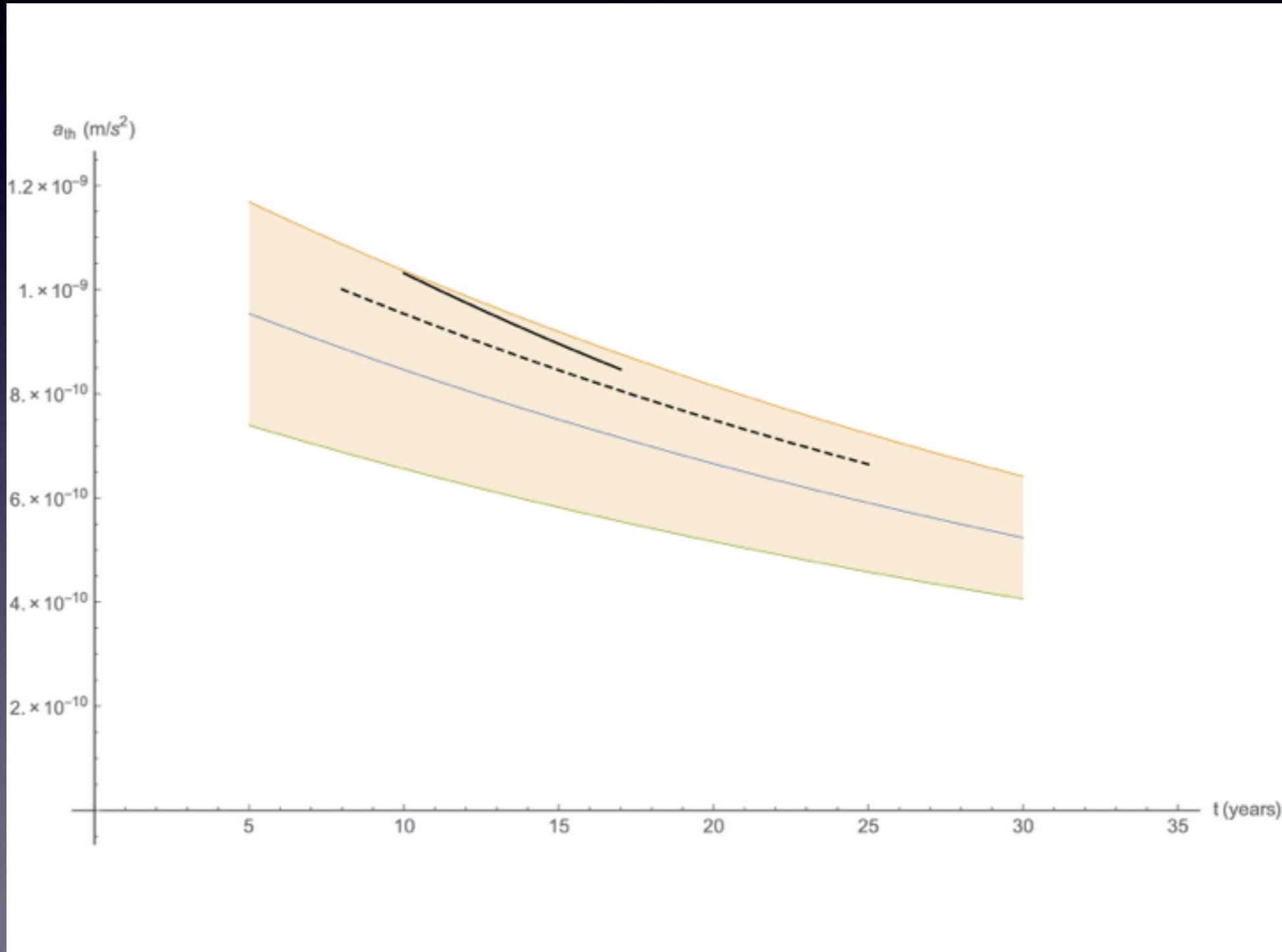


# Método Estatístico



$$a_{th}(26) = (5,8 \pm 1,3) \times 10^{-10} \text{ m/s}^2$$

# Assinatura Temporale



# Anomalia da Cassini?



O que nós sabemos...