

12 - Gravitational Assists, Flybys, and Deep Space Mission Profiles

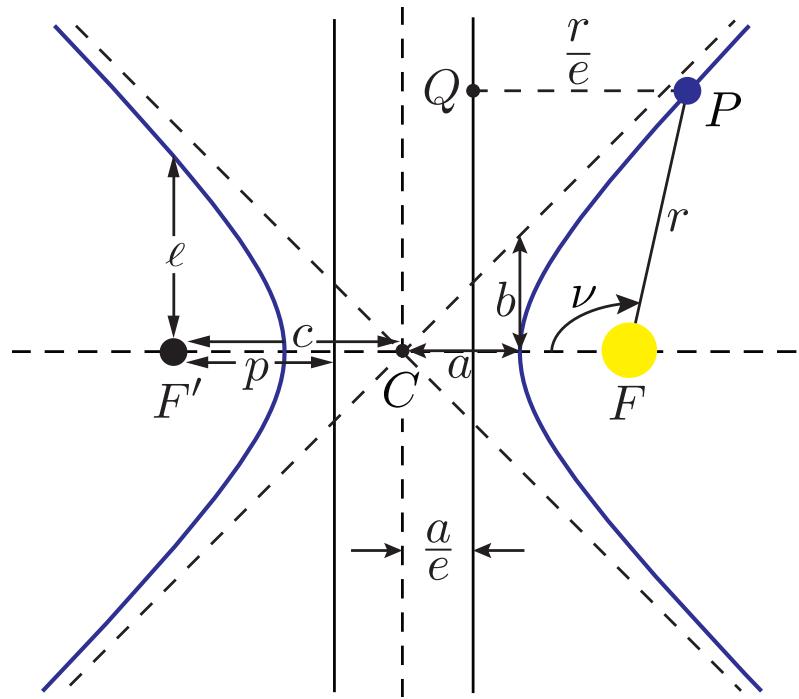
Dmitry Savransky

Cornell University

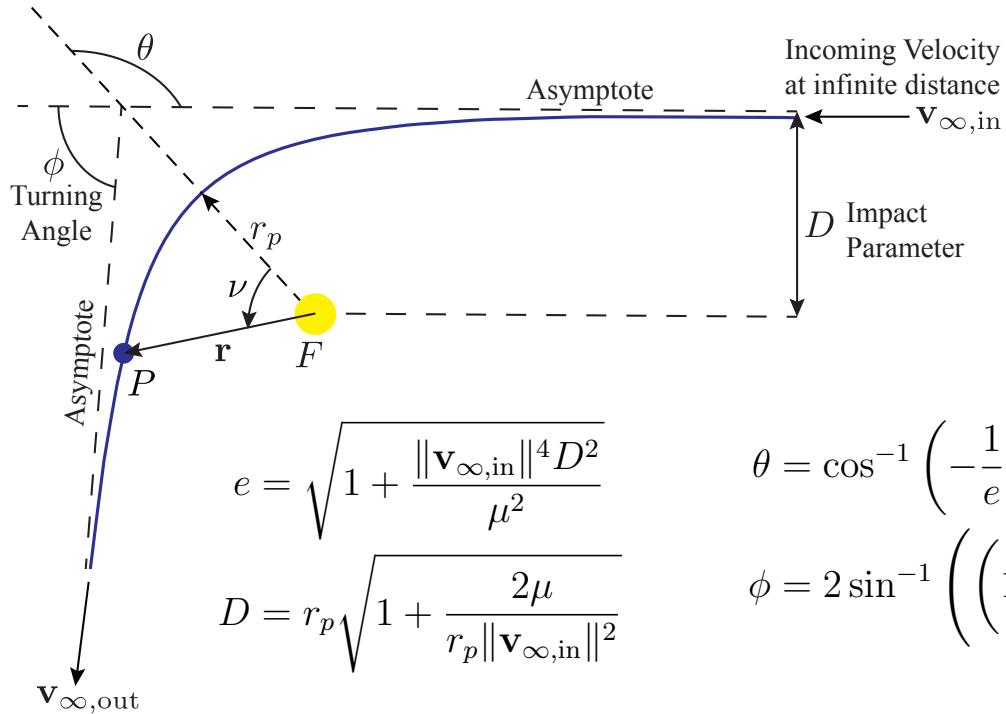
MAE 4060

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Recall Hyperbolic Orbits



Hyperbolic Flyby



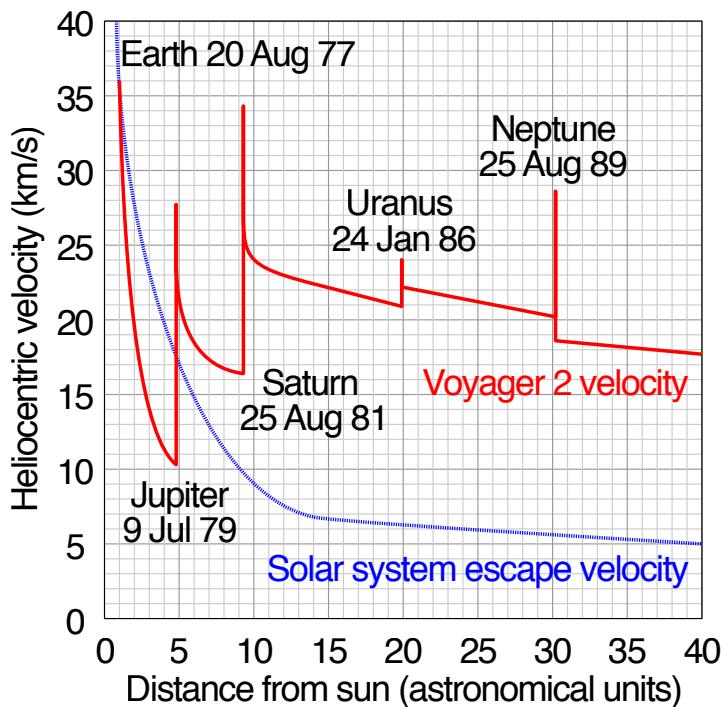
$$e = \sqrt{1 + \frac{\|\mathbf{v}_{\infty,\text{in}}\|^2 D^2}{\mu^2}}$$

$$D = r_p \sqrt{1 + \frac{2\mu}{r_p \|\mathbf{v}_{\infty,\text{in}}\|^2}}$$

$$\theta = \cos^{-1} \left(-\frac{1}{e} \right)$$

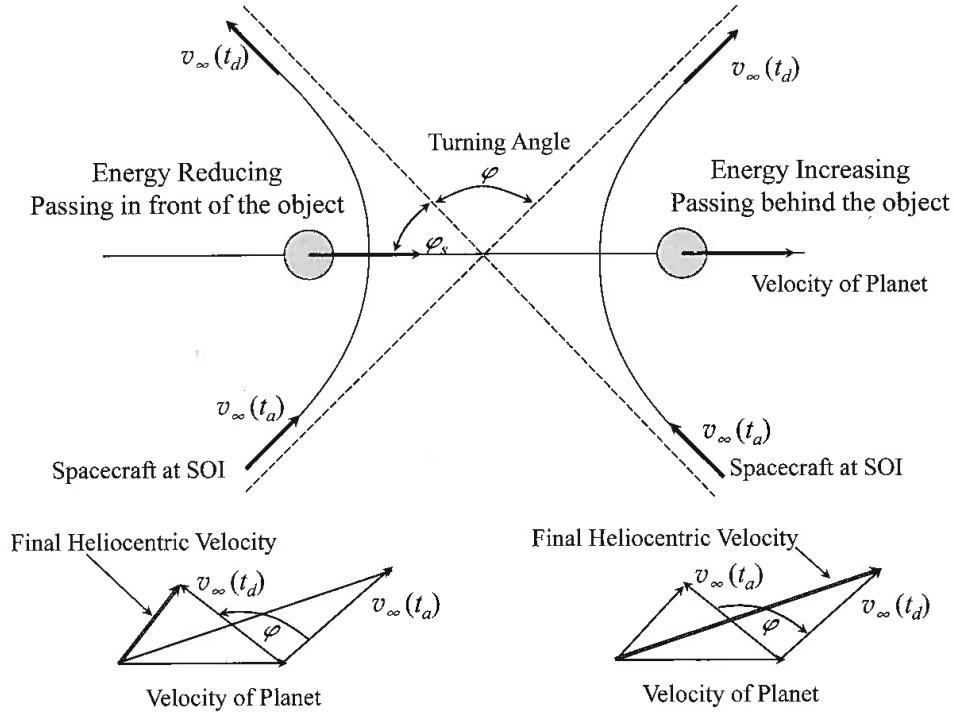
$$\phi = 2 \sin^{-1} \left(\left(1 + \frac{r_p \|\mathbf{v}_{\infty,\text{in}}\|^2}{\mu} \right)^{-1} \right)$$

Voyager 2



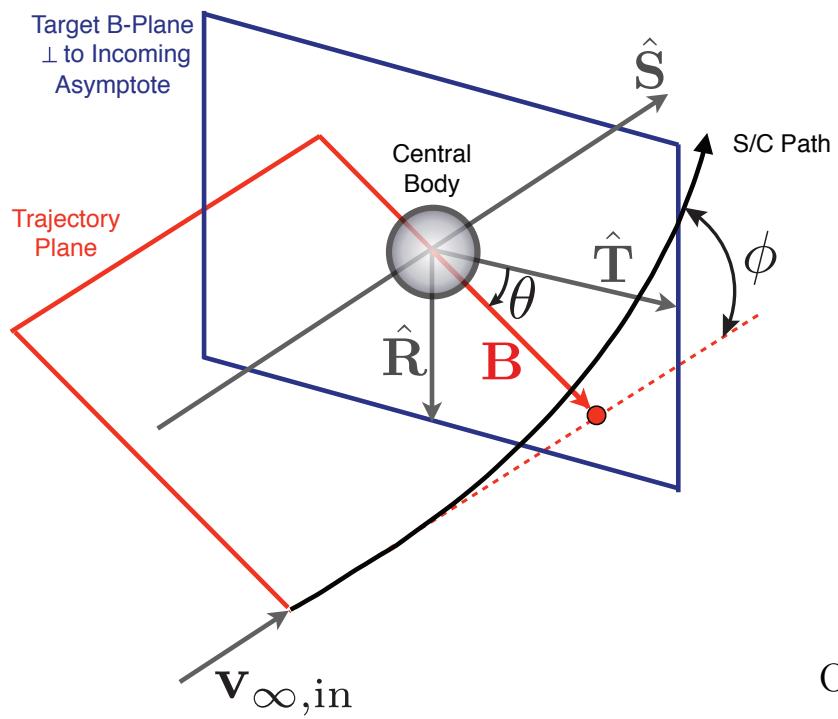
https://commons.wikimedia.org/wiki/File:Voyager_2_velocity_vs_distance_from_sun.svg

Flybys can be used to speed up or slow down



$\phi_s \equiv \theta$
Vallado (2013) Fig. 12-11

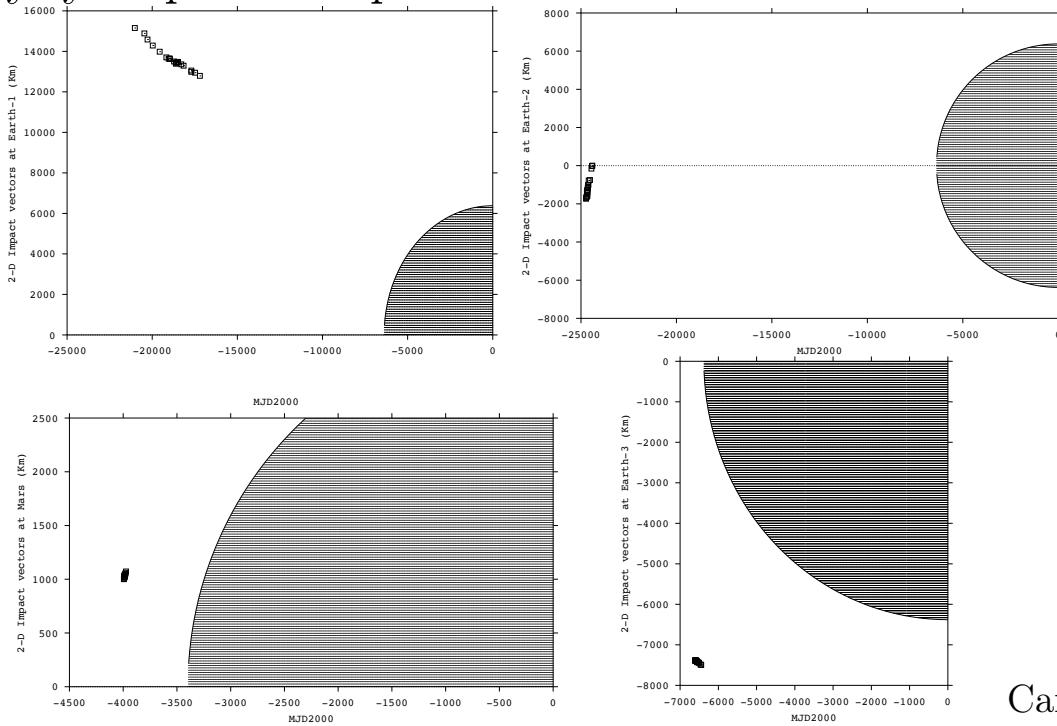
B-Plane Targeting



- $\hat{\mathbf{S}} \parallel$ to $\mathbf{v}_{\infty,\text{in}}$
- $\hat{\mathbf{R}} = \hat{\mathbf{S}} \times \hat{\mathbf{T}}$
- \mathbf{B} in perapse direction, with magnitude D
- $\hat{\mathbf{T}} \perp$ to $\hat{\mathbf{S}}$, \parallel to ecliptic

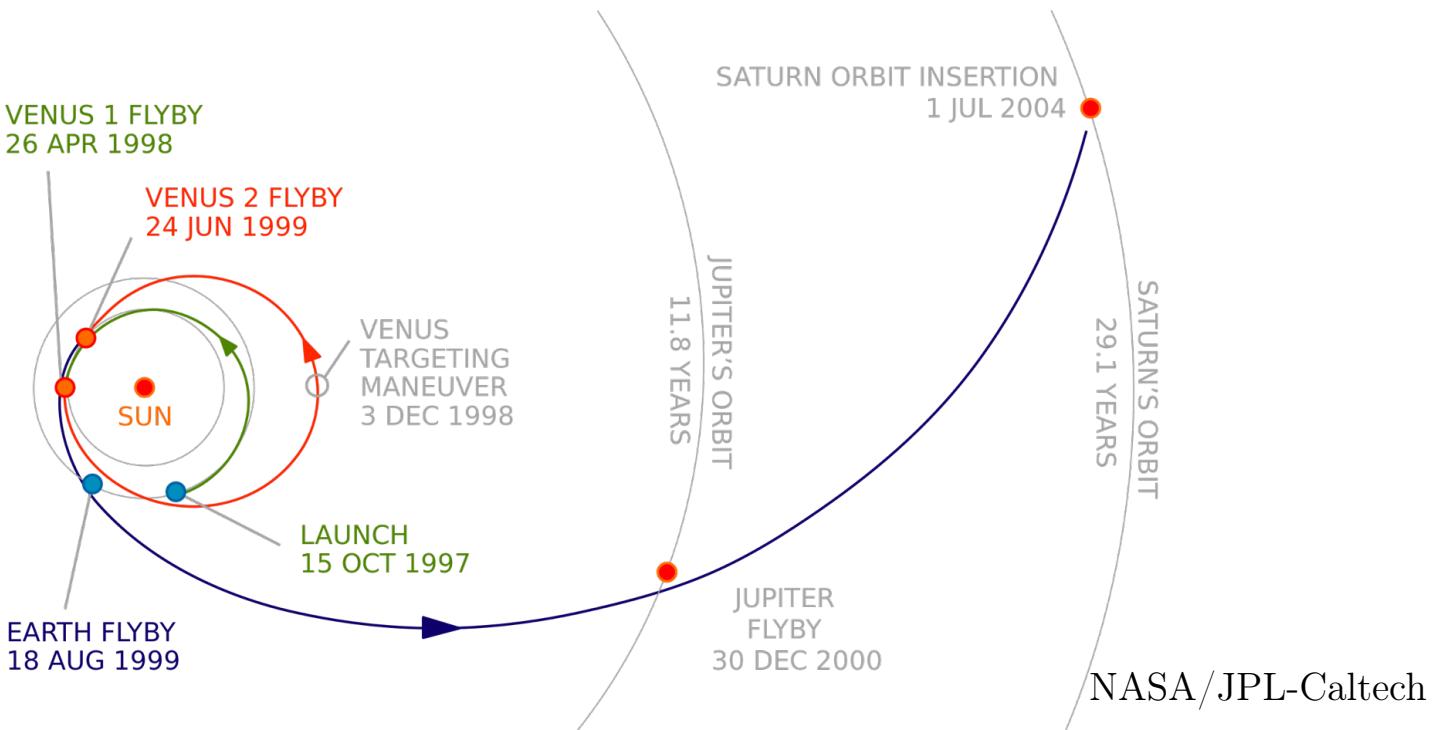
Orig. Figure by Kate Davis

Flyby B-plane Impact Vectors for ROSETTA

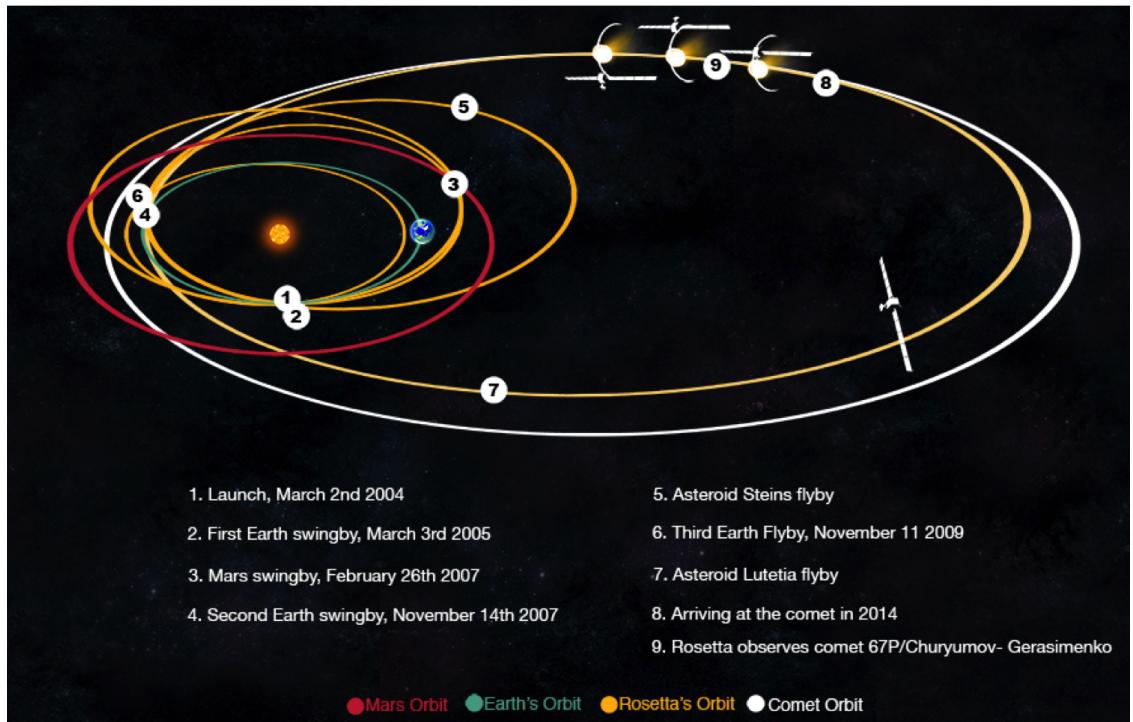


Canabal et al. (2004)

Cassini: VVEJGA



ROSETTA: EMEEGA



New Horizons: JGA

