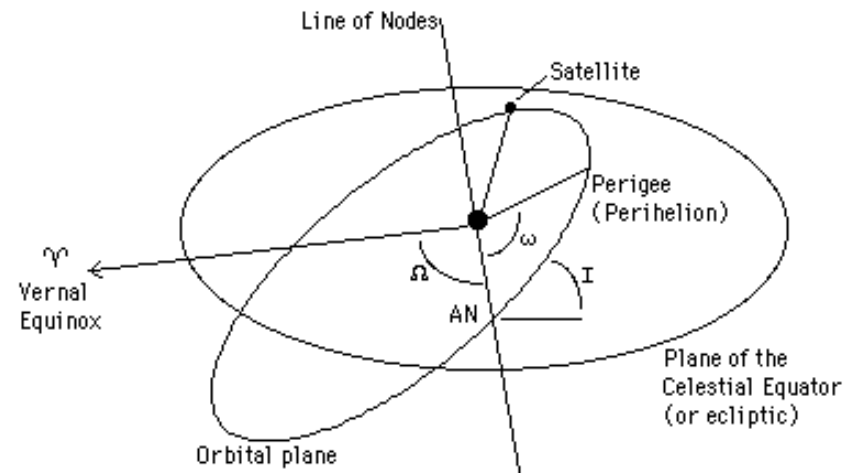
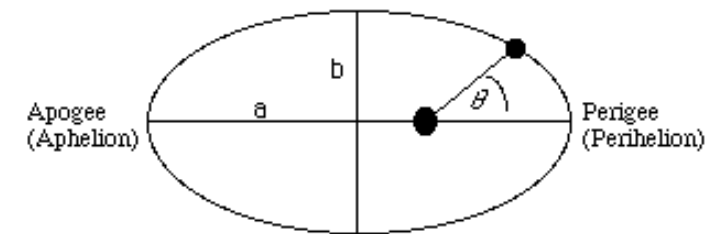
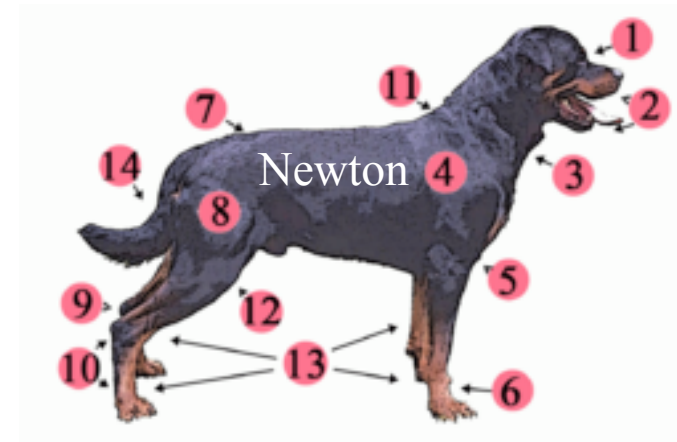


# Orbital Elements

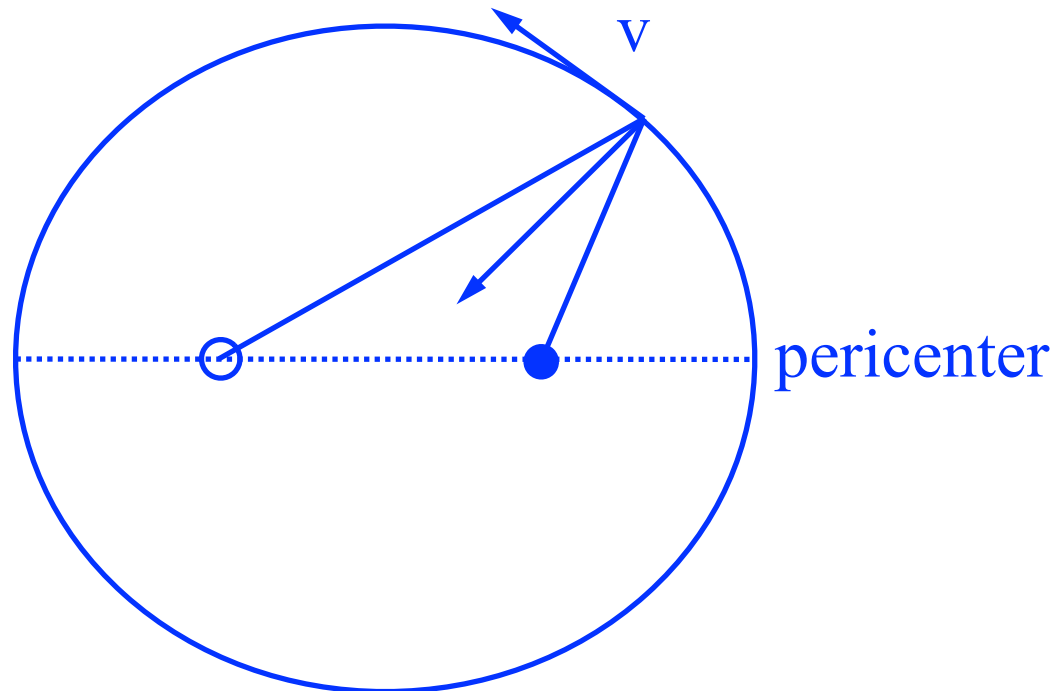
Reference planes: e.g.,  
 Ecliptic = Earth's orbital plane (specify epoch)  
 Invariable Plane = perpendicular to total angular momentum

- a: semimajor axis
- e: eccentricity
- f: true anomaly (from periapse)
- i: orbital inclination (0-90 prograde, 90-180 retrograde)
- $\Omega$ : longitude of ascending node
- $\omega$ : argument of periapse
- $\tilde{\omega} = \omega + \Omega$ : longitude of periapse, broken (dog-leg) angle



# All you need to know...

- sum of distances to two foci =  $2a$
- eccentricity  $e = \text{center-to-focus} / a$
- angle bisector is perpendicular to tangent
- $E$  is proportional to  $-1/a$
- Filled focus is fixed, empty focus is free



# $V_{\parallel}$ kick, at pericenter

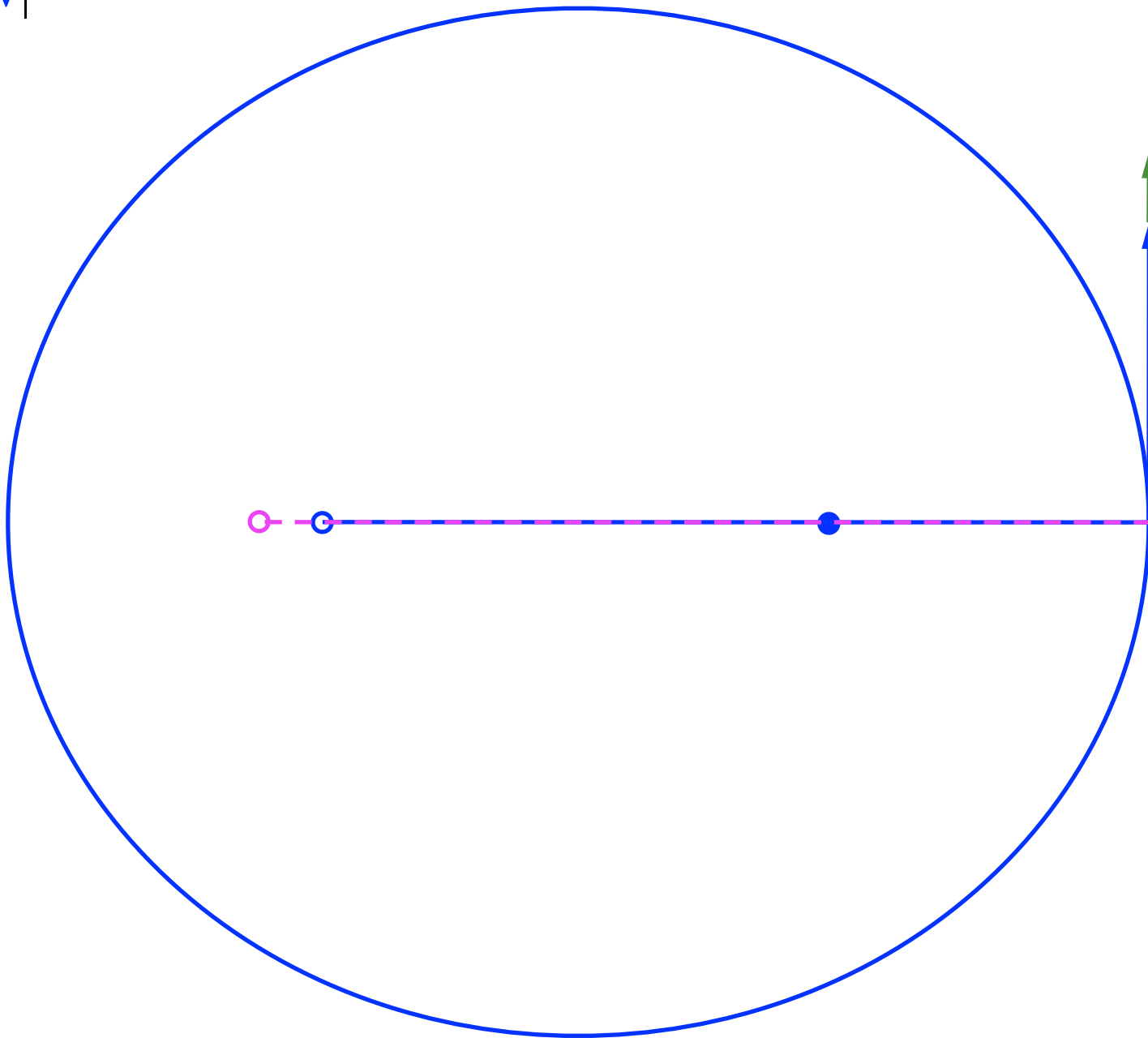
$$|\mathbf{v}'| > |\mathbf{v}|$$

$$E' > E$$

$$a' > a$$

$$e' > e$$

$$\omega' = \omega$$



# $V_{\perp}$ kick, after pericenter

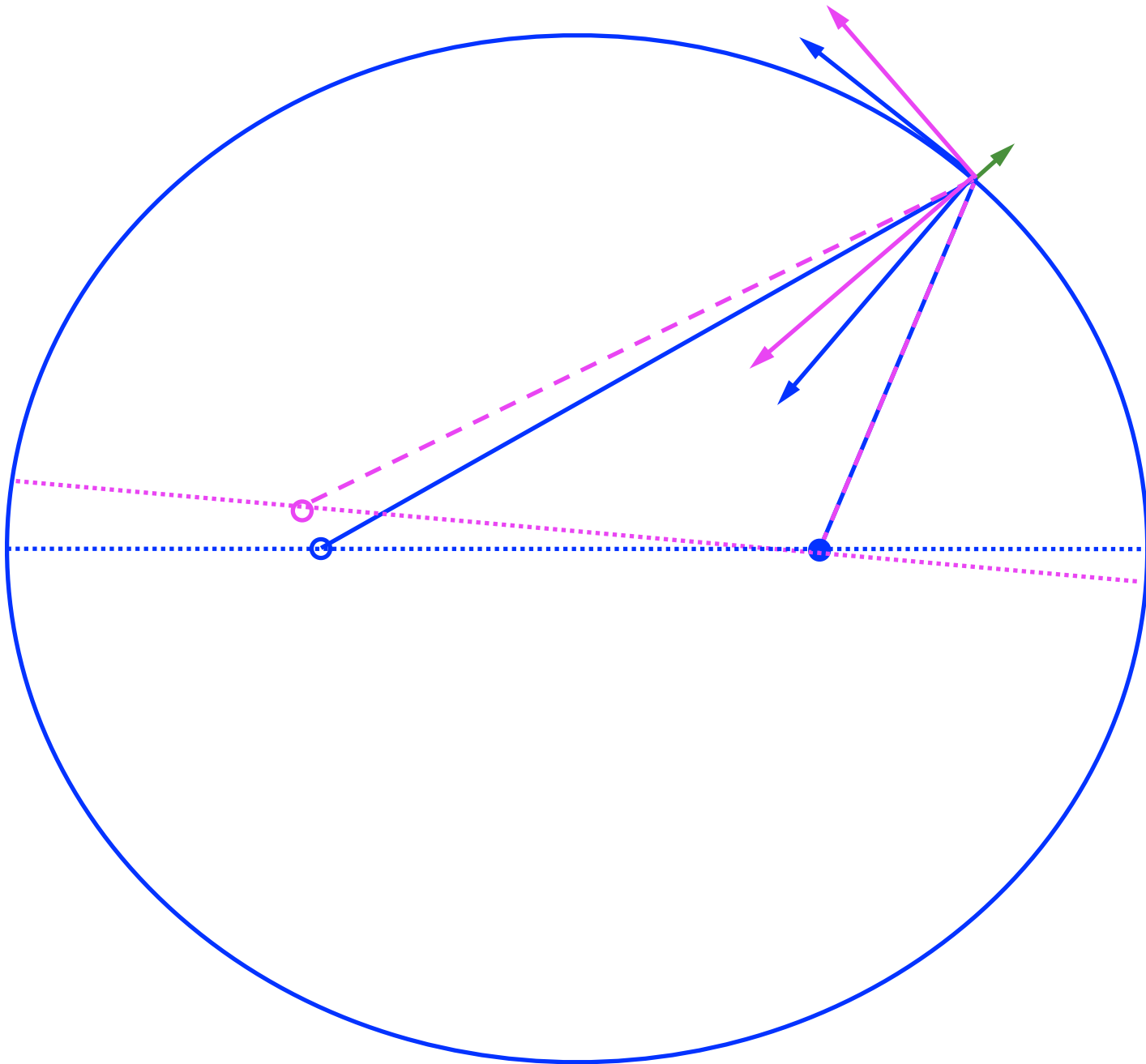
$$|\mathbf{v}'| = |\mathbf{v}|$$

$$E' = E$$

$$a' = a$$

$$e' > e$$

$$\omega' < \omega$$



# $V_{\parallel}$ kick, after pericenter

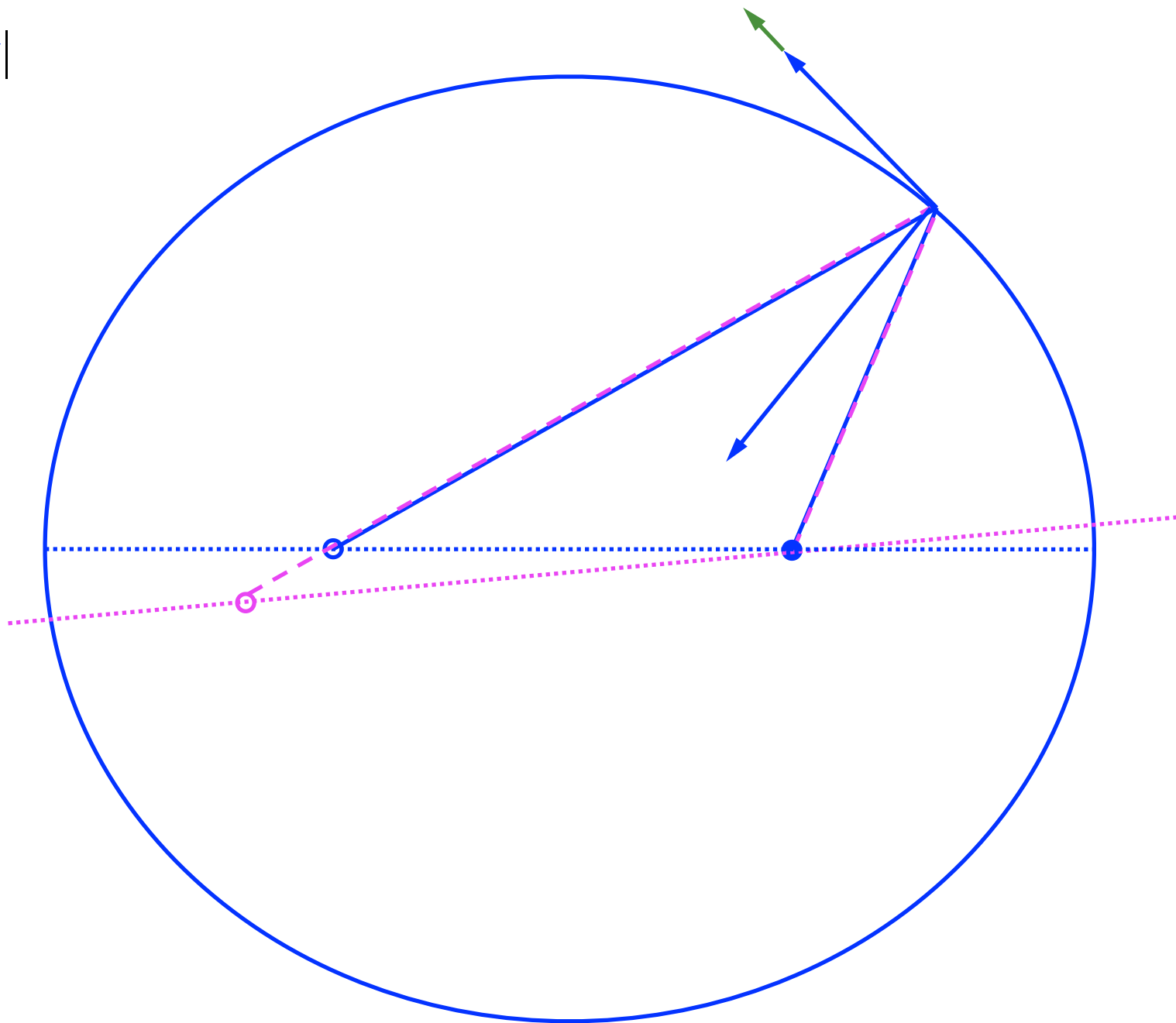
$$|\mathbf{v}'| > |\mathbf{v}|$$

$$E' > E$$

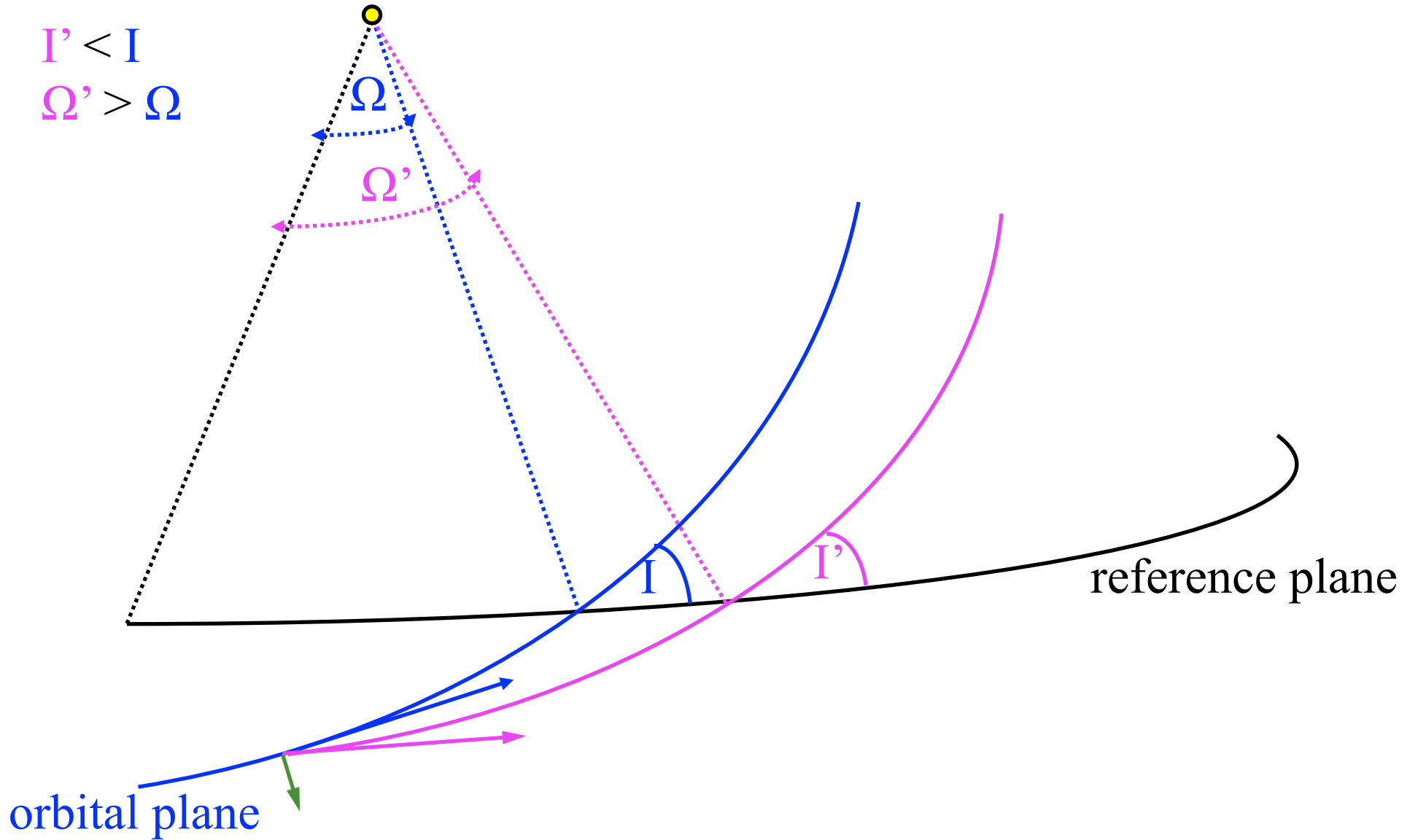
$$a' > a$$

$$\omega' > \omega$$

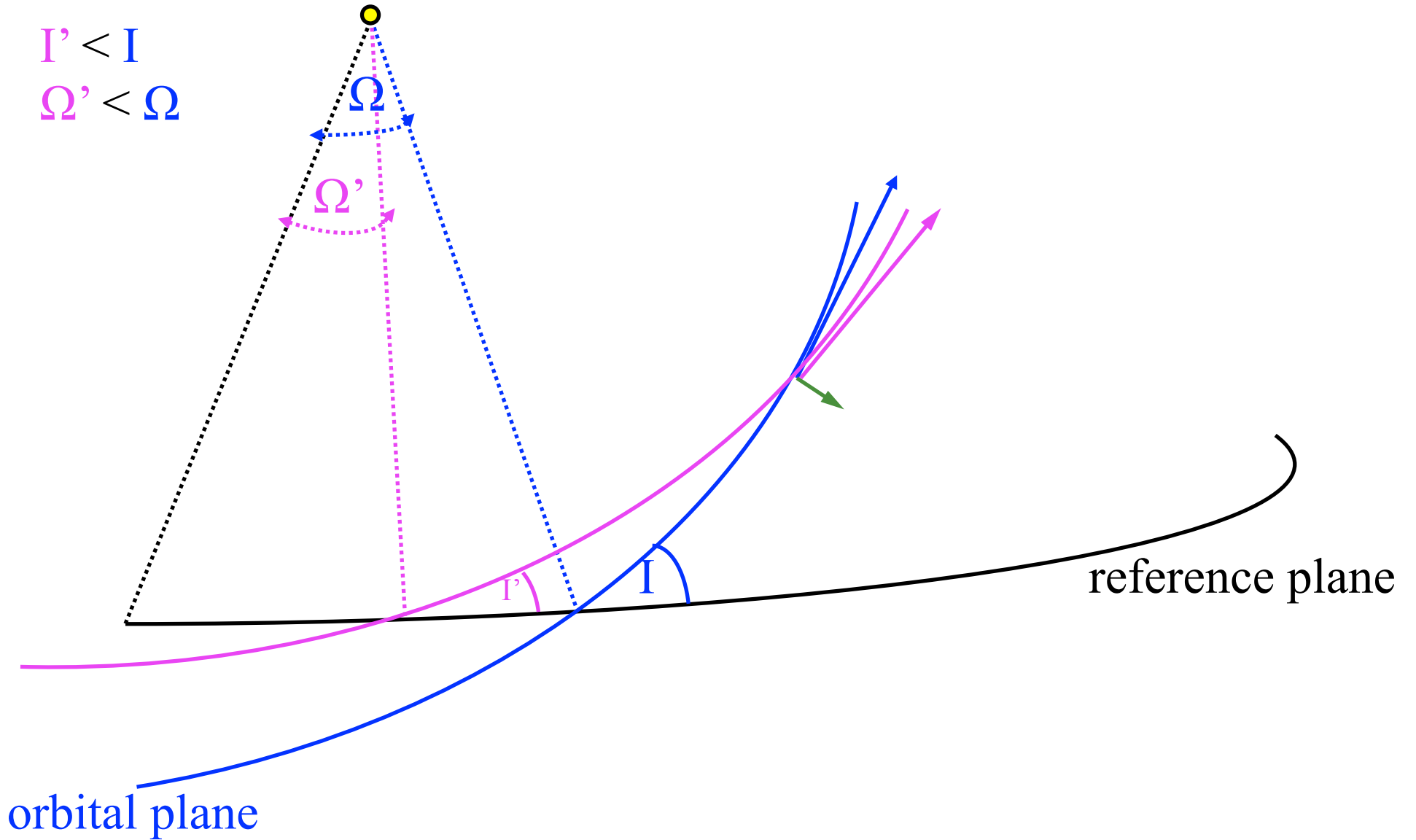
$$e' > e$$



$V_{\perp}$  kick, before ascending node

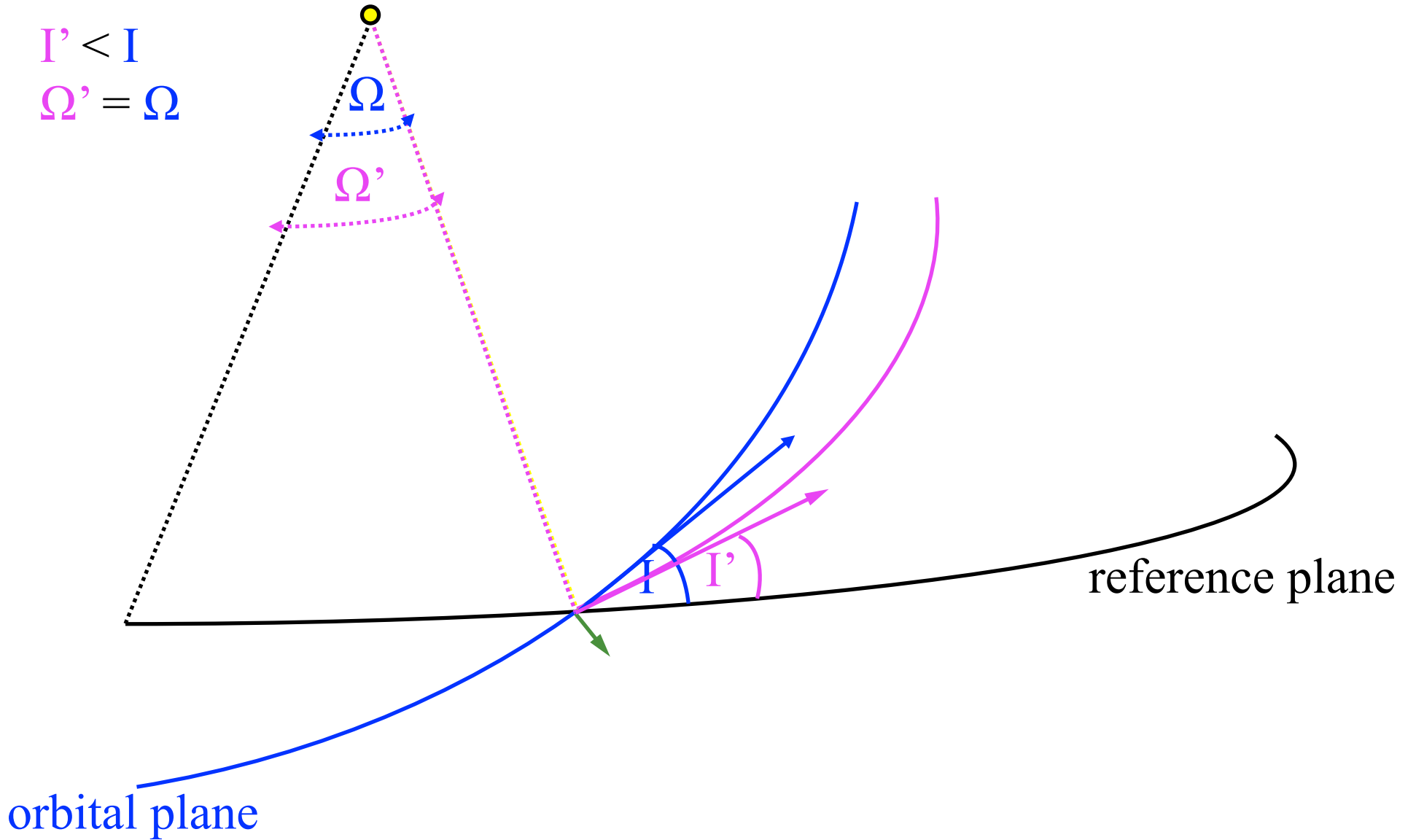


$V_{\perp}$  kick, after ascending node



$V_{\perp}$  kick, at ascending node

$I' < I$   
 $\Omega' = \Omega$





$V_{\parallel}$  kick, before ascending node

$$\begin{aligned} \Gamma' &= \Gamma \\ \Omega' &= \Omega \end{aligned}$$

