Theoretical Transit Area Model

Given:

R_s = stellar radius, R_p = planetary radius, τ = transit duration, t_0 = mid-transit time.

Define the **radius ratio**:

$$k = \frac{R_p}{R_s}.$$

The **transit chord length** is:

$$C = 2(1 + k).$$

The **relative velocity** (in stellar-radius units per second) is:

$$v_R = \frac{C}{\tau} = \frac{2(1 + k)}{\tau}.$$

At time t, the projected center-to-center separation is:

$$z(t) = \left| v_R (t - t_0) \right|.$$

Planet–Star Overlap Function

$$\lambda(z,k) = \begin{cases} 0, & z \geq 1 + k, \\ k^2, & z \leq 1 - k, \\ \dfrac{1}{\pi} \left[\cos^{-1}\left(\dfrac{z^2 + 1 - k^2}{2z} \right) + k^2 \cos^{-1}\left(\dfrac{z^2 + k^2 - 1}{2zk} \right) \right. & \\ \left. \qquad - \dfrac{1}{2} \sqrt{(-z + 1 + k)(z + 1 - k)(z - 1 + k)(z + 1 + k)} \right], & \text{otherwise.} \end{cases}$$

Transit Area (Integrated Flux Deficit)

$$A_{\text{theoretical}} = \int_{t_0 - \frac{\tau}{2}}^{t_0 + \frac{\tau}{2}} \lambda(z(t), k)\, dt.$$

Numerical midpoint approximation:

$$A_{\text{theoretical}} \approx \sum_i \frac{\lambda(t_{i+1}) + \lambda(t_i)}{2} \Delta t_i.$$

Model Comparison with Neural Network Output

$$\Delta A = A_{\text{NN}} - A_{\text{theoretical}}, \qquad \delta_{\%} = \frac{\Delta A}{A_{\text{theoretical}}} \times 100, \qquad \text{Agreement Score} = 100 - |\delta_{\%}|.$$

Classification rule:

$$\text{Final Label} = \begin{cases} \text{CONFIRMED EXOPLANET}, & \text{if Agreement Score} \geq 50 \text{ and disposition} \neq \text{FP}, \\ \text{CONFIRMED FALSE POSITIVE}, & \text{if Agreement Score} \geq 50 \text{ and disposition} = \text{FP}, \\ \text{POTENTIAL EXOPLANET}, & \text{if Agreement Score} < 50 \text{ and disposition} = \text{FP}, \\ \text{POTENTIAL FALSE POSITIVE}, & \text{otherwise.} \end{cases}$$