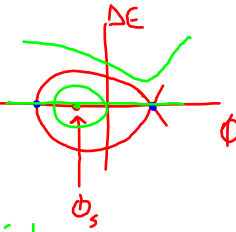


⑤

$$\Delta E^2 + D^2(\cos\phi + \phi \sin\phi_s) = \text{constant}$$



$$\Delta E = 0 \Rightarrow \cos\phi + \phi \sin\phi_s$$

$$\text{Extremum} \Rightarrow \frac{d}{d\phi}(\cos\phi + \phi \sin\phi_s) = 0$$

$$-\sin\phi + \sin\phi_s = 0$$

$$\text{Unstable fixed: } \sin\phi = \sin\phi_s$$

$$\phi \neq \phi_s$$

$$\phi = \pi - \phi_s$$

$$\text{Other extreme } \phi: \cos\phi_2 + \phi_2 \sin\phi_s = (\pi - \phi_s) \sin\phi_s$$

$$= \cos(\pi - \phi_s) + (\pi - \phi_s) \sin\phi_s$$

⑦

$$\Delta E = 20 \text{ TeV} - 2 \text{ TeV}$$

$$= 18 \text{ TeV in time of } 1500 \text{ s}$$

$$L = 87 \text{ km} = 8.7 \times 10^4 \text{ m}$$

$$\gamma > \frac{2 \text{ TeV}}{0.938 \text{ GeV}} = \frac{2000 \text{ GeV}}{0.938 \text{ GeV}} > 2000 \gg 1$$

$$\# \text{ passages} = \frac{1500 \text{ s} \times 2.9979 \times 10^8 \frac{\text{m}}{\text{s}}}{8.7 \times 10^4 \text{ m}}$$

$$= 5.2 \times 10^6$$

$$\frac{\text{Energy Gain}}{\text{Pass}} = \frac{18 \text{ TeV}}{5.2 \times 10^6} = \frac{18 \times 10^6 \text{ MeV}}{5.2 \times 10^6}$$

$$= 3.5 \text{ MeV/pass} = 15 \sin\phi_s$$

$$\sin\phi_s = \frac{3.5}{15} \Rightarrow \phi_s = \begin{cases} 13.4^\circ \\ 180 - 13.4^\circ \end{cases}$$