High Power Microwave Sources
ELC 746
Lecture 7

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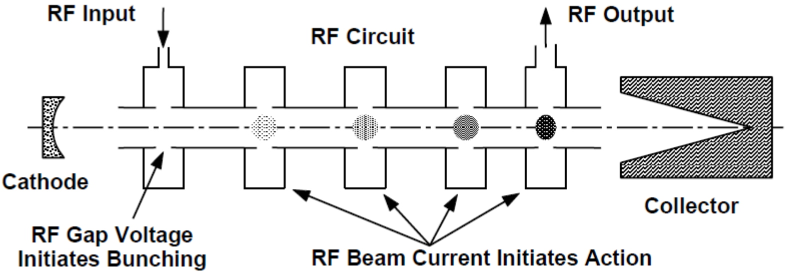
Klystron Velocity Modulation



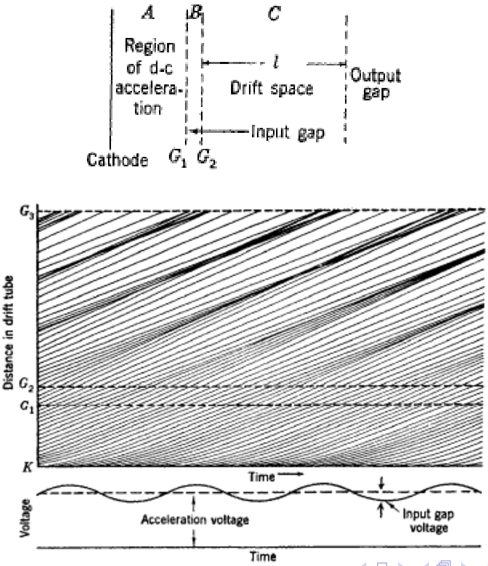
The equation of motion for electrons in the gap is,

$$\frac{1}{2}mu_0^2 = eV_0, \qquad \frac{1}{2}mu^2 - \frac{1}{2}mu_0^2 = eM_p V_1 \sin \omega t_0$$

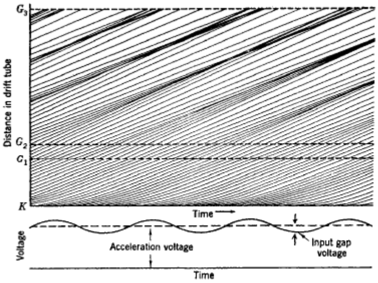
$$u = u_0 \sqrt{1 + \frac{M_p V_1}{V_0} \sin \omega t_0} \approx u_0 \left(1 + \frac{MV_1}{2V_0} \sin \omega t_0\right),$$

$$\text{where } M_p = \frac{\sin(\varphi_0/2)}{\varphi_0/2}, \qquad \varphi_0 = \omega \frac{\ell}{u_0}$$

Applegate Diagram of Electron Trajectories in Velocity Modulation and Bunching



Arrival Time Versus Exit Time



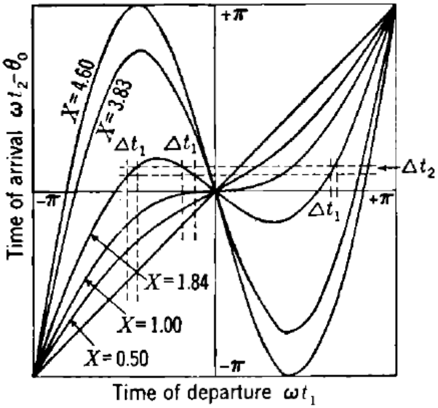
t_0 enterance time at G_1

t_1 exit time at G_2

t_2 arrival time at G_3

$$\omega t_2 = \omega t_1 + \frac{\omega l}{v} \approx \omega t_1 + \left(\frac{\omega l}{v_0}\right)\left[1 - \left(\frac{MV}{2V_0}\right)\sin(\omega t_1)\right]$$

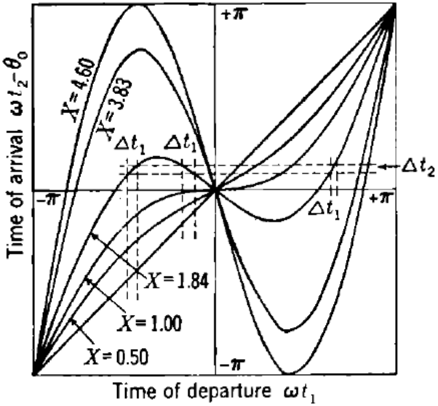
Arrival Time Versus Exit Time



$$\omega t_2 = \omega t_1 + \theta_0 - X_0 \sin\left(\omega t_1\right),$$

where $\theta_0 \omega l / v_0$, and $X_0 = \dfrac{MV\theta_0}{2V_0}$.

Current Calculation



Conservation of charges gives,

$$i_2 \left|\Delta t_2\right| = I_0 \Sigma_{t_1(t_2)} \left|\Delta t_1\right|$$

$$i_2 = I_0 \Sigma_{t_1(t_2)} \left|\frac{dt_1}{dt_2}\right|$$

Current Calculation

$$i_2 = I_0 \Sigma_{t_1(t_2)} \left| \frac{1}{1 - X_0 \cos(\omega t_1)} \right|$$