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New Directions in Plasma Physics.

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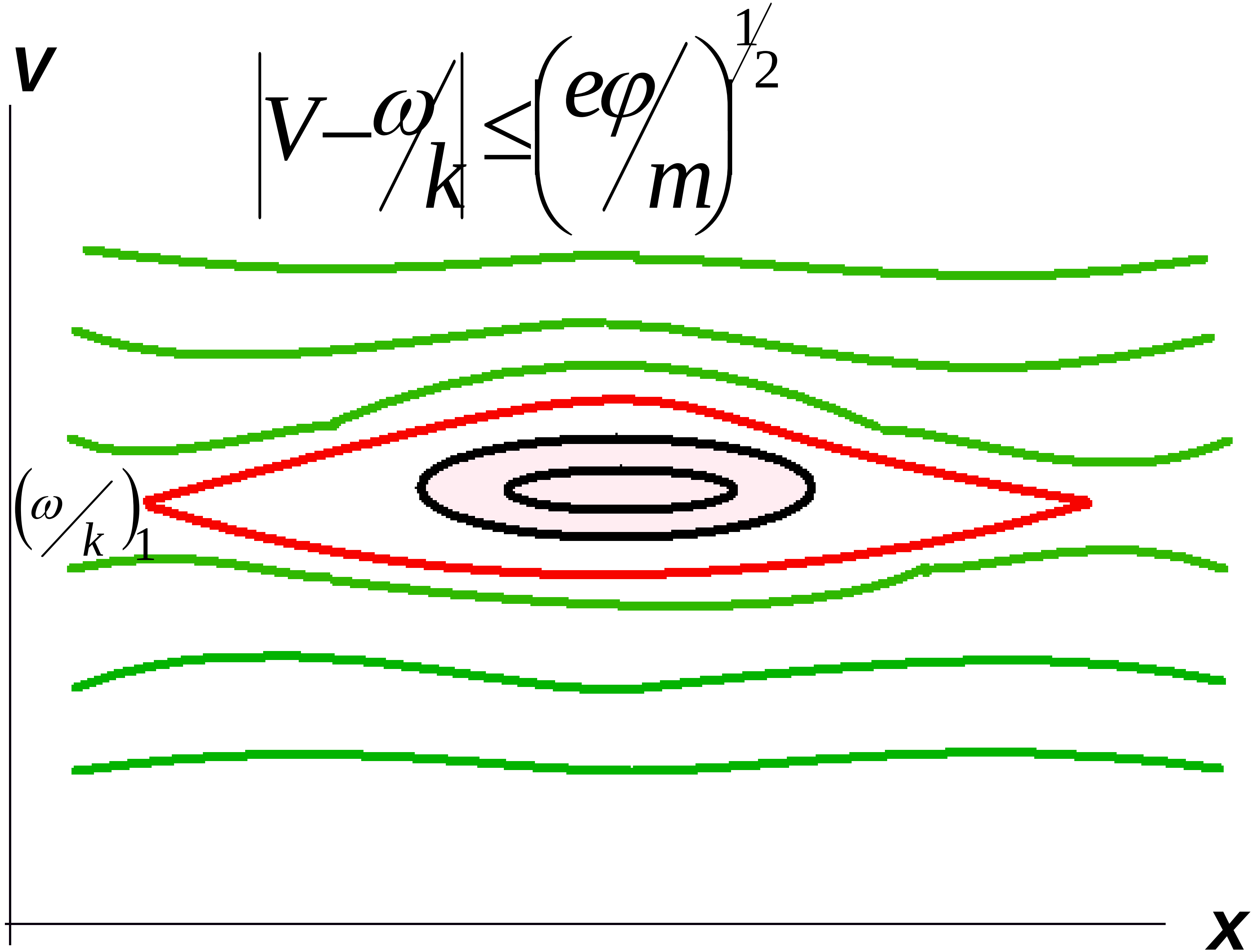
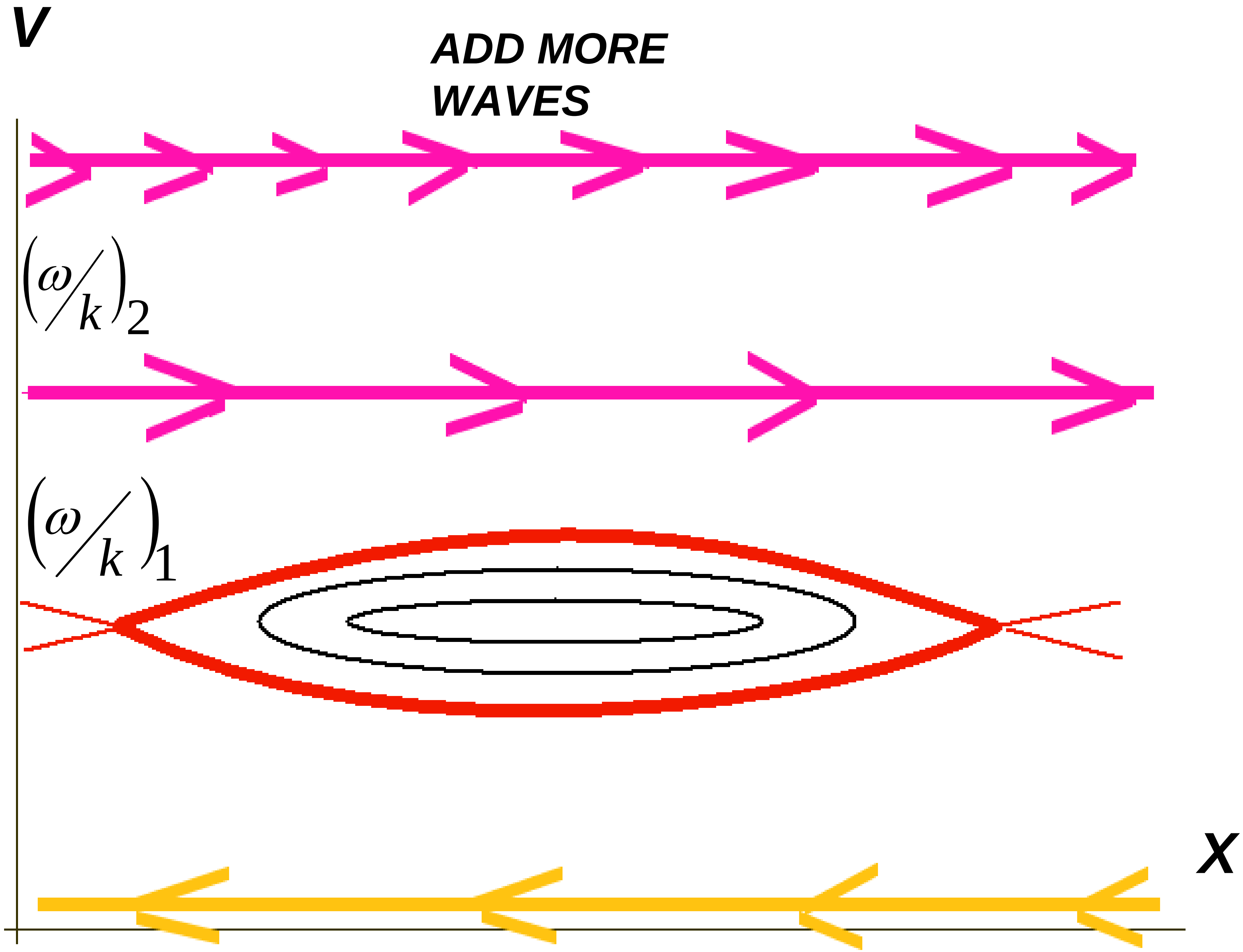
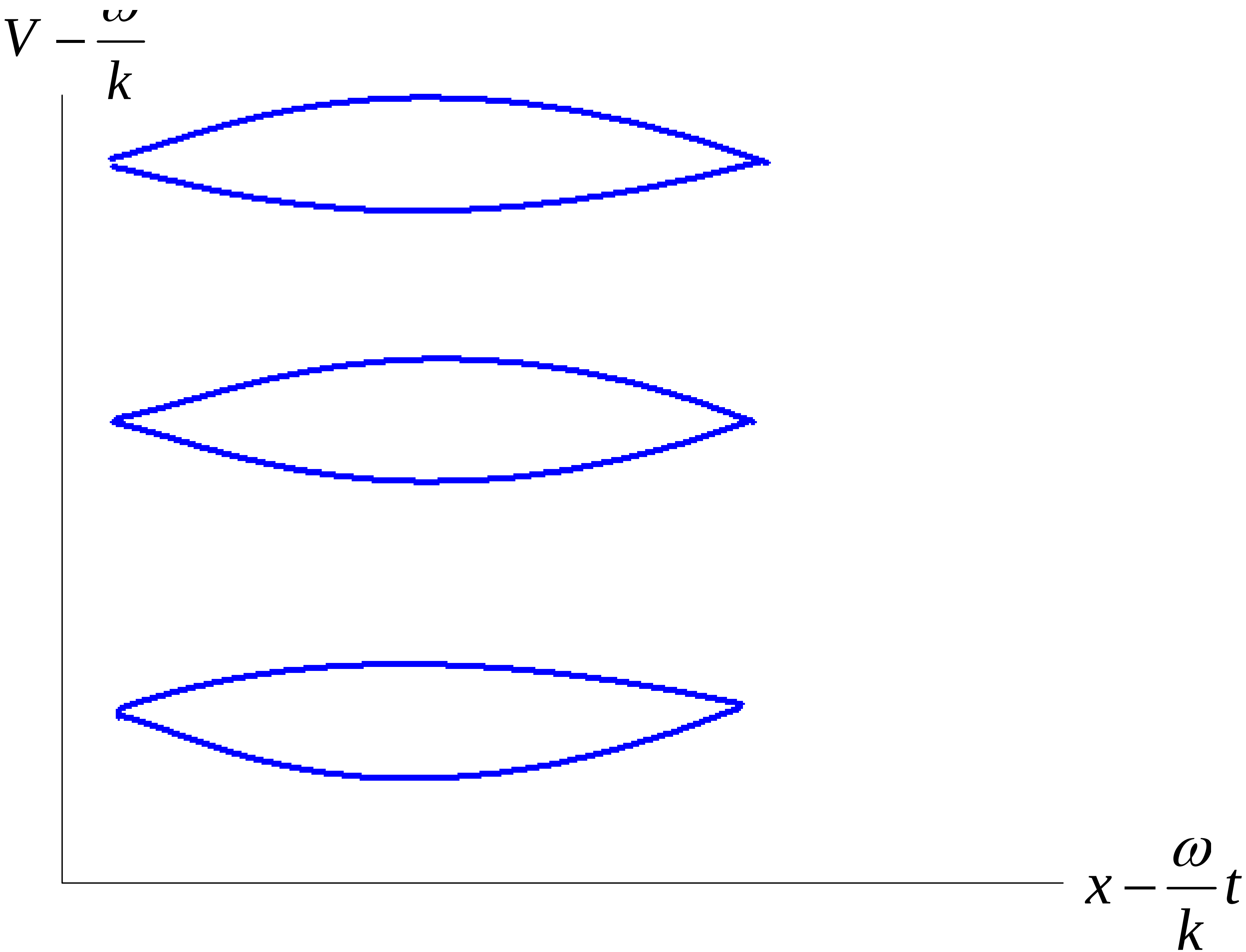
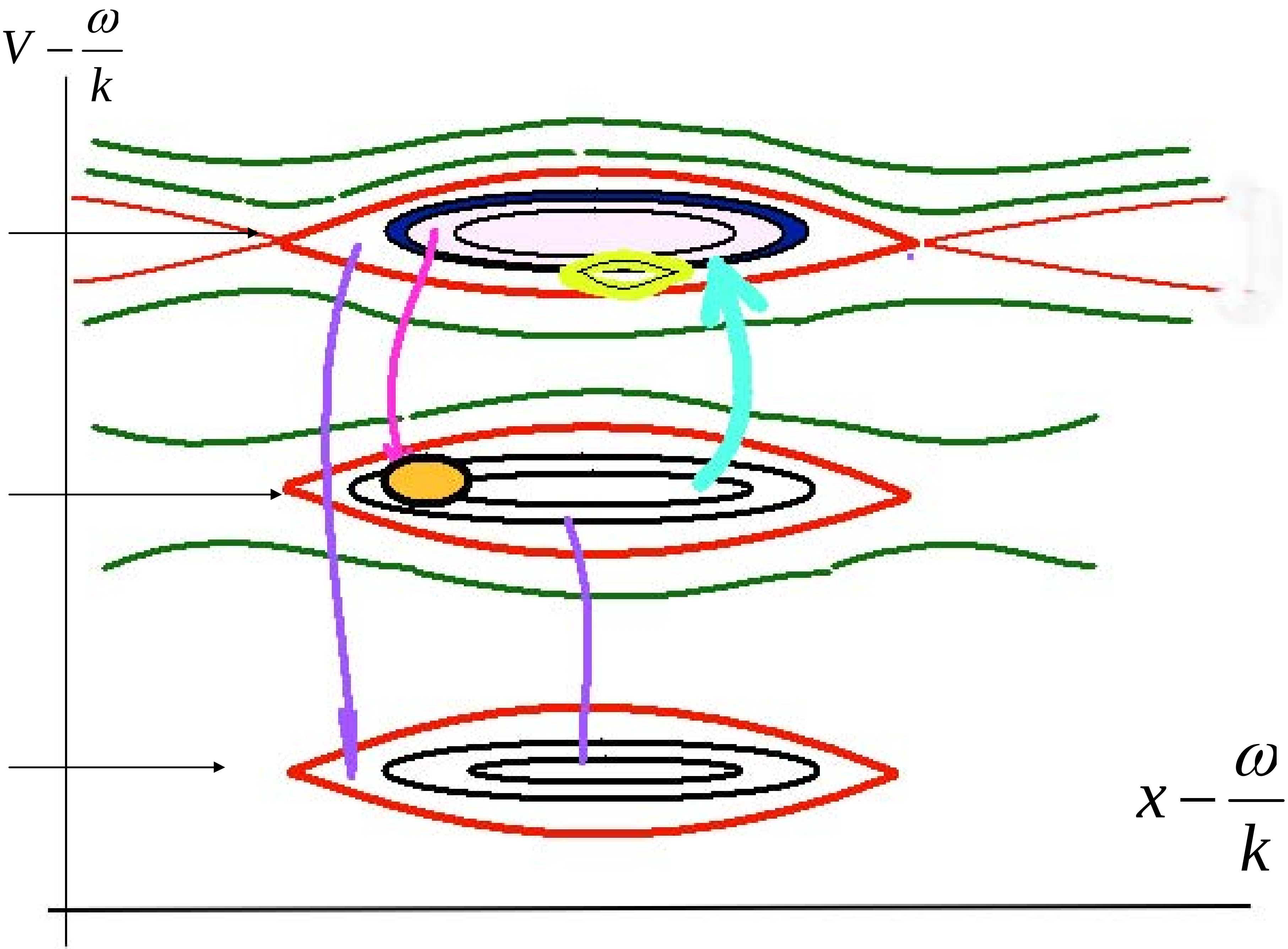
$$m \frac{dV}{dt} = e \sum E_i \exp i\left(\omega_i - kv\right)t$$


V
$\left|V-\omega/k\right| \le \left(e\varphi/m\right)^{1/2}$
$\left(\omega/k\right)_1$
X


V
ADD MORE WAVES
$(\omega/k)_2$
$(\omega/k)_1$
X


$V-\frac{\omega}{k}$
$x-\frac{\omega}{k}t$



$V-\frac{\omega}{k}$
$x-\frac{\omega}{k}$

$$\left|V - \omega/k\right| \le \left(e\varphi/m\right)^{1/2}$$

Width of resonance

vs.

$$\left(\omega/k\right)_{n+1} - \left(\omega/k\right)_{n}$$

Distance between resonances

$$\left({e\varphi}/{m} \right)^{1/2} \text{ much less than } \left({\omega}/{k} \right)_{n+1} - \left({\omega}/{k} \right)_{n}$$

This limit corresponds to KAM (Kolmogoroff-Arnold-Mozer) case.

KAM-Theorem :

As applied to our case of Charged Particle – Wave Packet Interaction –

"Particle preserves its orbit "

$$\left(\frac{e\varphi}{m}\right)^{1/2} \quad \textit{greater than} \quad \left(\frac{\omega}{k}\right)_{n+1} - \left(\frac{\omega}{k}\right)_{n}$$

That means - overlapping of neighboring resonances

Repercussions:

-"collectivization" of particles between neighboring waves;

-particles moving from one resonance to another – "random walk"? And if yes

- what is Diffusion Coefficient ?(in velocity space)

$$m\frac{dV}{dt} = e\sum E_i \exp i(\omega_i - kv)t$$

$$V = {}^{e}\!/_{m}\sum E_i \exp i(\omega - kv)t \Big/ i(\omega - kv)$$

***V*×*dV/dt* =**

$$e^2 \Big/ m^2 \sum\sum EE^* \exp i(\omega_i - \omega_j - k_i v + k_j v)t \Big/ i(\omega - kv)$$

$$V^2 \propto Dt$$

D= $\pi e^2 / m^2 \sum |E|^2 \delta(kv - \omega)$

$$\sum_k = \frac{1}{2\pi} \int dk$$

Repercussions: Quasilinear Theory, Plateau Formation,

Beam + Plasma Instability Saturation etc.

General Conclusions

- Kolmogoroff: Application of KAM theory to the Dynamics of Planetary System
- Plasma case: Application to the Dynamics of Charged Particles

more applications:

- Waves-Particles interaction at Cyclotron Resonance
- Magnetic Surfaces Splitting? (Trieste, 1966)
- Advection in Fluids (+20 years)

$$B_z = B_0; B_y = {}^{x}\!/_{L_s} B_0$$

$$b_x = b_\perp Cos\left(k_z z + k_y y\right)$$

$$\frac{dx}{dl} = {}^{b_\perp}\!/_{B_0}\, Cos\left(k_z z + k_y y\right)$$

$$dy / dl = x / L_s$$

$$y = x_0 l / L_s + 1 / L_s \int_{x_0}^{x} x dl$$

$$k_z = -k_y \left({}^{x_0}\!/_{L_s} \right)$$

$$dx / dl = b_\perp / B_0 Cos\left(\frac{k_y}{Ls} \int x dl\right)$$

$$dv/dt = e/mECos(k\int vdt)$$

$$b_{\perp}/B_0 \propto (e/m)E$$

$$k_y/L_s \propto k \qquad x \propto v$$

$$\delta v = (e\varphi/m)^{1/2} \propto \delta x = b_{\perp}/B_0 (L_s/k_y)^{1/2}$$