$$\omega_k = 2\Omega \frac{k_z}{k}$$

$k_\perp \ll k_\parallel$

$$\delta(\omega_k - \omega_{k_1} - \omega_{k_2}) = \frac{1}{2\Omega}\delta\left(\frac{|k_z|}{k} - \frac{|k_{1z}|}{k_1} - \frac{|k_z - k_{1z}|}{k_\perp - k_{1\perp}}\right)$$

$$\frac{|k_z - k_{1z}|}{k_\perp - k_{1\perp}} \approx \left|(k_z - k_{1z})\right| \cdot \left[\frac{1}{k_{1\perp}} - (n_\perp \cdot n_\perp)\frac{k}{k}\right]$$

$$= \frac{|k_z|}{k_\perp} - \frac{|k_{1z}|}{k_{1\perp}} \Rightarrow \frac{k_z}{k_{1\perp}} - \frac{k_z \cdot k_z}{k_\perp^2}(n_\perp - n_\perp) + \cdots$$

$$- \frac{k_{1z}}{k_{1\perp}} + \frac{k_{1z}k_z}{k_\perp^2}(n_\perp \cdot n_\perp) - \frac{k_z}{k_\perp} + \frac{k_{1z}}{k_{1\perp}} = 0$$

$$= \frac{k_z}{k_\perp} - \frac{k_{1z}}{k_{1\perp}} \Rightarrow \frac{k_{1z}}{k_{1\perp}} - \frac{k_z^2 k_{1\perp}}{k_\perp^2}(n_\perp \cdot n_\perp)$$

$$- \frac{k_{1z}}{k_\perp} + \frac{k_{1z}k_{1\perp}}{k_\perp^2}(n_\perp \cdot n_\perp) - \frac{k_z}{k_\perp} + \frac{k_{1z}}{k_{1\perp}} = 0$$

$$\Rightarrow \frac{k_{1z}}{k_{1\perp}} = \frac{k_z k_{1\perp}}{k_\perp^2}(n_\perp \cdot n_\perp)$$

$$\delta(\omega_k - \omega_{k_1} - \omega_{k_2}) = \frac{k_{1\perp}}{2\Omega}\delta\left(k_{1z} - \left(\frac{k_{1\perp}}{k_\perp}\right)^2 (k_z) \cdot (n_\perp \cdot n_\perp)\right)$$

$u_k \sim k_\perp^{-5/2} k_z^{-3/2}$ $\quad u_{k_1} \sim k_{1\perp}^{-5/2} \cdot k_{1z}^{-3/2}$

$$u_{k_1}/u_k \sim \left(k_\perp^{-5/2} \cdot k_z^{-3/2} \cdot k_{1\perp}^{5/2} \cdot k_{1z}^{3/2}\right)^{-1} \sim \left(\left(\frac{k_\perp}{k_{1\perp}}\right)^{-5/2} \cdot \left(\frac{k_z}{k_{1z}}\right)^{-3}\right)^{-1}$$

$$\frac{i\sqrt{\Omega}}{32\pi^3}\cdot\frac{k_z^* k_{1\perp}\,[n_{1\perp}\times n_\perp]^2}{k_\perp^2\cdot k_z\sqrt{k_{1\perp}\cdot k_{1z}}}=\frac{k_{1\perp}\,[n_{1\perp}\times n_\perp]^2 k_\perp k_z}{\sqrt{k_z}\;k_{1\perp}^2\sqrt{k_{1\perp}}\;k_\perp^2(n_\perp n_\perp)^{\frac{1}{2}}32\pi^3}$$

$$\sim -2\cdot\frac{i\sqrt{\Omega}}{32\pi^3}\cdot[n_{1\perp}\times n_\perp]^2\cdot\frac{\sqrt{k_z}}{k_\perp\cdot\sqrt{k_{1\perp}}}$$

$$f\sim\frac{}{2^9\pi^5}|k_z|/k_\perp^2\Big/(n_\perp\cdot n_{1\perp})^4\cdot[n_\perp\cdot n_{1\perp}]^{-2}\cdot$$

$$\delta\left(k_{1\perp}-\left(\frac{k_{1\perp}}{k_\perp}\right)^2(n_{1\perp}\cdot n_\perp)\cdot k_z\right)$$

$$I_k\sim\int d\Theta_k\,(n_\perp\cdot n_{1\perp})^{-3/2-1}\int_0^{\sim k}k_{1\perp}^{2+1-11/2}=\int_0^k\frac{dk_{1z}}{k^{5/2}\sqrt{k_{1\perp}}}$$

РАСХ-ТЬ

2) $k_{1\perp}\gg k_\perp$

$$\delta(\omega_k+\omega_{k_1}-\omega_{k_1})=\frac{1}{2\Omega}\delta\left(\frac{k_z}{k_\perp}+\frac{k_{1z}}{k_{1\perp}}-\frac{|k_z-k_{1z}|}{k_\perp-k_{1\perp}}\right)$$

$$\frac{k_z}{k_\perp}+\frac{k_{1z}}{k_{1\perp}}=|k_z-k_{1z}|\cdot\left(\frac{-1}{k_{1\perp}}-\frac{k_\perp}{k_{1\perp}^2}\cdot(n_\perp\cdot n_{1\perp})\right)$$

$$\frac{k_z}{k_\perp}+\frac{k_z}{k_{1\perp}}\pm\frac{k_{1z}\,k_\perp}{k_{1\perp}^2}(n_\perp\cdot n_{1\perp})=0$$

$$h_{k_1} \sim h_k \cdot \left(\frac{k_{1\perp}}{k_\perp}\right)^{-11/2}$$

$$V^k_{k_1 k_2} \sim \frac{[k_{1\perp} \times k_{2\perp}]^2 \sqrt{k_{1\perp} \cdot k_\perp^2}\ \sqrt{2\Omega}}{k_\perp \cdot k_{1\perp} \cdot k_{2\perp} \sqrt{k_{1\perp} k_{2\perp}}} \cdot \frac{i}{32\pi^3} \cdot f(\omega)$$

$$\sim \frac{[k_{1\perp} \times k_{2\perp}]^2 \cdot i}{k_\perp k_{2\perp} \sqrt{k_{1\perp} \cdot k_{1\perp}}} \cdot \frac{i\sqrt{2}}{32\pi^3} \cdot f(\omega)$$

$$f(\omega) = \omega_k^2 (k_{2\perp}^2 - k_{1\perp}^2) + \omega_1^2 (k_{1\perp}^2 - k_{2\perp}^2) + \omega_2^2 (k_{1\perp}^2 - k_{2\perp}^2)$$

$$= \left(\frac{k_z}{k_\perp}\right)^2 \cdot \Big(\cancel{k_{1\perp}^2 - k_{1\perp}^2} \cancel{k_{1\perp}^2} + k_\perp^2 + 2k_\perp k_{1\perp} + \cancel{k_{1\perp}^2} - k_{1\perp}^2) +$$

$$\left(\frac{k_{1z}}{k_{1\perp}}\right)^2 \cancel{\omega_1^2} \left(\cancel{k_{1\perp}^2} + k_\perp^2 + 2k_\perp k_{1\perp} - \cancel{k_{1\perp}^2}\right) + \left(\frac{k_z}{k_\perp}\right)^2 \left(k_{1\perp}^2 - k_\perp^2\right)$$

$$\approx \frac{k_z^2}{k_\perp^2} \cdot \Big[\cancel{k_\perp^2} - 2k_\perp k_{1\perp} + \cancel{k_{1\perp}^2} - \cancel{k_\perp^2} - k_\perp^2 \cdot \frac{k_{1\perp}^2}{k_\perp^2} + 2k_\perp \cdot \cancel{k_{1\perp}} \cdot \frac{k_{1\perp}^2}{k_\perp^{\cancel{2}}} \Big] (n_{1\perp} \cdot n_\perp)^2 \Big] \sim \frac{k_z^2}{k_\perp^2} \Big[-2k_{1\perp} k_\perp$$

$$\cdot \left(1 - (n_{1\perp} \cdot n_\perp)^2\right) + k_{1\perp}^2 \left(1 - (n_{1\perp} \cdot n_\perp)^2\right) \sim$$

$$\frac{k_z^2}{k_\perp^2} \cdot 2 \cdot k_{1\perp} \cdot k_\perp$$

$$V^k_{k_1 k_2} \sim \frac{i\sqrt{\Omega}\ k_z^2 k_{1\perp} \cdot [(n_{1\perp} \times n_\perp)]^2 \sim}{32\pi^3 \quad k_\perp^2 \cdot k_{2\perp} \sqrt{k_{1\perp} k_{2\perp}}}$$

$$\delta(\omega_k + \omega_{k_1} - \omega_{k_2}) = \frac{1}{2\Omega} \cdot \delta\left(\frac{k_z}{k_\perp} - \frac{k_{1z}\, k_z}{k_{1\perp}^2}(\mathbf{k}_\perp \cdot \mathbf{k}_{1\perp})\right)$$

$$= \frac{k_\perp}{2\Omega}\left(\delta\left(k_z - k_{1z}\left(\frac{k_\perp}{k_{1\perp}}\right)^2 (\mathbf{k}_\perp \cdot \mathbf{k}_{1\perp})\right)\right)$$

$$\frac{k_{1k}}{k_k} \propto \frac{k_z^{+3/2}\, k_\perp^{5/2}}{k_{1z}^{3/2}\, k_{1\perp}^{5/2}} \qquad k_{1z} \sim k_z\left(\frac{k_{1\perp}}{k_\perp}\right)^2 (\mathbf{k}_\perp \cdot \mathbf{k}_{1\perp})$$

$$\Rightarrow k_{1k} \sim \left(\frac{k_{1\perp}}{k_\perp}\right)^{-11/2} \cdot (\mathbf{k}_\perp \cdot \mathbf{k}_{1\perp})^{3/2}$$

$$V = -\frac{i\sqrt{2\Omega}}{32\sqrt{2}\pi^3} \cdot \frac{k\,[\mathbf{k}_{1\perp} \times \mathbf{k}_{2\perp}]^2 \cdot k_{1\perp}^2 \sqrt{k_{1\perp}^2 \cdot k_z}}{k_\perp \cdot k_{1\perp}^2 \sqrt{k_z k_{1z}^2}} \cdot f(\omega)$$

$$f(\omega) = \omega_k^2 (k_{z\perp}^2 - k_{1\perp}^2) + \omega_1^2 (k_{1\perp}^2 - k_{2\perp}^2) + \omega_2^2 (k_{2\perp}^2 - k_\perp^2) \approx \left(\frac{k_z}{k_\perp}\right)^2 \left(k_{1\perp}^2 - 2k_{1\perp}k_\perp - k_{1\perp}^2\right) + \omega\left(\frac{k_{1z}}{k_{1\perp}}\right)^2 \cdot \left(k_{1\perp}^2 - k_{1\perp}^2 + 2k_{1\perp}k_\perp - k_{2\perp}^2\right) + \left(\frac{k_{1\perp}}{k_{1\perp}}\right)^2 \cdot k_{1z}$$

$$\cdot \left(k_{1\perp}^2 - k_\perp^2\right) \approx \left(\frac{k_z}{k_\perp}\right)^2 \cdot \left[-2k_{1\perp}k_\perp + \right.$$

$$\left. + \left(\frac{k_{1z}}{k_{1\perp}^2} k_z\right)^2 \cdot \frac{k_\perp^2}{k_z^2} \cdot \frac{(\mathbf{k}_\perp \cdot \mathbf{k}_{1\perp})^2}{} \left\{2k_{1\perp} \cdot k - k_\perp^2 + k_{1z}^2 - k_\perp^2\right\}\right] =$$

$$\left(\frac{k_2}{k_1}\right)^2\left[-2k_{1\perp}k_\perp + \frac{k_{1\perp}^2}{k_\perp^2}\{k_{1\perp}^2\}\cdot(u_\perp\cdot u_{1\perp})^{-1}\right]$$

$$V^K_{k_1k_2} \sim \frac{-i\sqrt{2\Omega}}{32\sqrt{2}\pi^3}\cdot[u_{1\perp}\times u_\perp]^2\cdot\frac{k_{1\perp}}{\sqrt{k_\perp}\cdot k_{1z}\sqrt{k_z}}\cdot$$

$$\cdot k_z^2/k_\perp^2\cdot\frac{k_{1\perp}^2}{k_\perp^2}k_{1\perp}^2\cdot(u_\perp\cdot u_{1\perp})^{-1}\sim$$

$$\sim\frac{-i\sqrt{\Omega}}{32\pi^3}\cdot[u_{1\perp}\times u_\perp]^2 2\frac{k_{1\perp}^5\cdot k_z^{3/2}}{k_\perp^{9/2}\ k_{1z}(u_\perp\cdot u_{1\perp})}\sim$$

$$\sim\frac{-i\sqrt{\Omega}}{32\pi^3}2[u_{1\perp}\times u_\perp]^2\frac{k_{1\perp}k_z^{1/2}}{k_\perp^{5/2}\cdot}(u_\perp\cdot u_{1\perp})^{-1}$$

$$f(k,k_1)\sim\frac{|k_z|}{2^9\pi^5}k_\perp^{-3}\cdot([u_{1\perp}\times u_\perp]^2)^2k_{1\perp}^2$$

$$(u_\perp\cdot u_{1\perp})^{-2}$$

$$I_k\sim\int d\Omega_k(u_\perp\cdot u_{1\perp})^{3/2-2}\int_{\sim k}^{\infty}dk_{1\perp}k_{1\perp}^{2-1+2-11/2}=$$

$$=\int\frac{dk_{1\perp}}{k_{1\perp}^{5/2}}-\text{сх-ТСД}$$

3) $|V|^2 \sim \partial^2 k^2 \qquad R \sim \frac{v^2 k^2}{\omega_k} \cdot A^2 k^{-6+2s}$

$I_{k2} \sim A^2 \partial^2 k^{-2+2s} \cdot k \sim A^2 \partial^2 k^{-1+2s}$

$\epsilon_1 = \int I_1 \omega_k d^d k \sim A^2 \partial^2 \int_0^q k^{-1+2s} d k \Big|_{s \to 0} \sim$

$d=2$

$\sim A^2 \partial^2$

$\epsilon_{k2} = I_{k2} \sim A^2 \partial^2 k^{-3+2s}$

$\epsilon_2 \sim \int I_2 \omega_k d^d k \sim A^2 \partial^2 \int_0^q k^{-3} k^2 d^d k \sim$

$d=1$

$\sim \int_0^q k^{-2} \cdot A^2 \partial^2 \sim A^2 \partial^2 / q$