$$\omega_k = 2\Omega \frac{k_z}{k_\perp}$$

$k_{1\perp} \ll k_\perp$

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

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

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

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

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

$$n_k \sim k_\perp^{-5/2} k_z^{-3/2} \qquad n_{k_1} \sim k_{1\perp}^{-5/2} k_{1z}^{-3/2}$$

$$\frac{n_{k_1}}{n_{k_2}} \sim \left(k_\perp^{5/2} k_z^{3/2} \cdot k_{1\perp}^{-5/2} k_{1z}^{-3/2}\right) \sim \left(\frac{k_\perp}{k_{1\perp}}\right)^{5/2}\left(\frac{k_\perp}{k_{1\perp}}\right)^{-3}\cdot(n_{1\perp}\cdot n_\perp)^{-3/2}$$

$$n_{k_1} \sim n_k \left(\frac{k_{1\perp}}{k_\perp}\right)^{-11/2}\cdot(n_{1\perp}\cdot n_\perp)^{-3/2}$$

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

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

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

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

$$+\left(\frac{k_z}{k_\perp}\right)^2\left(k_{1\perp}^2 - k_\perp^2\right) \approx \left(\frac{k_z}{k_\perp}\right)^2\left[\cancel{k_\perp^2} - 2k_\perp k_{1\perp} + \cancel{k_{1\perp}^2}^{\to 0} - \cancel{k_\perp^2} - k_\perp^2 \cdot \cancel{\frac{k_{1\perp}^2}{k_\perp^2}}^{\to 0}(n_\perp n_{1\perp})^2\right]$$

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

$$V^k_{k,k_1} \sim \frac{i\sqrt{\Omega}}{16\pi^3}[n_{1\perp}\times n_\perp]^2 \cdot \frac{k_{1\perp}}{2\cdot k_z\sqrt{k_{1z}\cdot k_{1\perp}}} \cdot f(\omega) =$$

$$= \frac{-i\sqrt{\Omega}}{16\pi^3}[n_{1\perp}\times n_\perp]^2 \cdot \frac{k_z\cdot k_{1\perp}^2}{k_z\sqrt{k_{1z}\cdot k_{1\perp}}} \sim \frac{-i\sqrt{\Omega}}{16\pi^3}[n_{1\perp}\times n_\perp]^2 \cdot \frac{k_{1\perp}^{3/2}\sqrt{k_z}}{\sqrt{k_{1z}}\sqrt{k_\perp\cdot k_{1\perp}}}$$

$$\frac{1}{(n_{1\perp}\cdot n_\perp)} \sim \frac{-i\sqrt{\Omega}}{16\pi^3}[n_{1\perp}\times n_\perp]^2 \cdot (n_{1\perp}\cdot n_\perp)^{-1/2}\cdot\sqrt{k_z}\cdot(k_{1\perp})^{1/2}$$

$$f(k,k_1) \sim \frac{([n_{1\perp}\times n_\perp])^2}{2^9\pi^5}\cdot(n_{1\perp}\cdot n_\perp)^{-1}\cdot k_\perp k_{1\perp}^2\,\delta\left(k_{1z}-\left(\frac{k_{1\perp}}{k_\perp}\right)^2 k_z\cdot(n_{1\perp}\cdot n_\perp)\right)$$

$$I_k \sim \int_{(n_{1\perp}\cdot n_\perp)}^{\sim k} S^{-5/2}\,do_k \int_0^{\sim k} dk_{1\perp}\, k_{1\perp}^{2+1+2-\frac{11}{2}} \sim \int_0^{\sim k} dk_{1\perp}\cdot\frac{1}{\sqrt{k_{1\perp}}}$$

$$\Rightarrow k_{1z} \gg k_\perp:$$

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

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

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

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

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

$$\frac{u_{k_1}}{u_{k_2}} \propto k_\perp^{5/2}\cdot k_{1z}^{-5/2}\cdot k_z^{3/2}\cdot k_{1z}^{-3/2} \sim k_\perp^{5/2}\cdot k_\perp^{3/2}\cdot k_{1\perp}^{-5/2}\cdot\left(k_z\cdot k_\perp^{-2}k_{1\perp}^2(n_\perp\cdot n_{1\perp})\right)^{-3/2} \sim$$

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

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

$$f(\omega) \sim \left(\omega_k^2 (k_{2\perp}^2 - k_{1\perp}^2) + \omega_1^2 (k_{1\perp}^2 - k_{2\perp}^2) + \omega_2^2 (k_{1\perp}^2 - k_\perp^2)\right) \approx$$

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

$$+ k_{1\perp}^2 - k_\perp^2 \Big] \sim \left(\frac{k_z}{k_\perp}\right)^2 \left[k_\perp^2 - 2k_\perp k_{1\perp} + \frac{k_\perp^2}{k_z^2}\left(\frac{k_z k_{1\perp}^8}{k_\perp^2}\right)^2 (n_\perp \cdot n_{1\perp})^{-2} \cdot \right.$$

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

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

$$V = \frac{-i\sqrt{\Omega}}{32\pi^3} [n_{1\perp} \times n_\perp]^z \cdot \frac{k_{1\perp}^2 \cdot \sqrt{k_{1\perp}^2 \cdot k_\perp}}{k_{1\perp}^2 \cdot k_\perp \sqrt{k_z k_{1z}^2}} \cdot \frac{k_z^2}{k_\perp^2} \cdot \frac{k_{1\perp}^2 k_{1\perp}^2}{k_\perp^2} (n_1 \cdot n_{1\perp})^{-2} \approx$$

$$\sim \frac{-i\sqrt{\Omega}}{32\pi^3} [n_{1\perp} \times n_\perp]^z \frac{k_z^{3/2} \cdot k_{1\perp}^5}{k_\perp^{9/2} k_{1z}} (n_1 \cdot n_{1\perp})^{-2}$$

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

$$V_{k_1 k_2}^k \sim \frac{-i\sqrt{\Omega}}{32\pi^3} [n_{1\perp} \times n_\perp]^z \frac{\sqrt{k_z}\, k_{1\perp}^3}{\sqrt{k_\perp}\, k_\perp^2} (n_\perp \cdot n_{1\perp})^{-1}$$

$$f(k, k_1) \sim \frac{1}{2^{11}\pi^5} \left([n_{1\perp} \times n_\perp]^z\right)^2 (n_\perp \cdot n_{1\perp})^{-2} \cdot \frac{k_z}{k_\perp^3} k_{1\perp}^6 \cdot k_\perp \cdot$$

$$\cdot \delta\left(k_z + \frac{k_\perp^2 k_1}{k_{1\perp}^2} (n_\perp \cdot n_{1\perp})\right)$$

$$I_k \sim \int (n_\perp \cdot n_{1\perp})^{-7/2} do_k \int dk_{1\perp} \cdot k_{1\perp}^{2-1-\frac{11}{2}+6} \sim \int_{\sim k}^{\infty} k_{1\perp}^{3/2} dk_{1\perp} \text{ - расход}$$

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

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

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

$d=2$

$\sim A^2 \partial^2$

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

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

$d=1$

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