§6. Controlling the Cross-field-flux of Cold α-Particles with Resonant Magnetic Perturbations in a Helical Fusion Plasma Device

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A new scenario to control transport of "cold" α-particle flux in the Force Free Helical Reactor [1] by changing poloidal field (PF) coil current during plasma discharge is proposed here. A way to enhance the radial transport of the α-particles in the intermediate energy range is considered which relies on specific features of helical magnetic field. These are the β-induced change in the B/B_0 modulation along the particle trajectory to remove helically trapped cold α-particles [2] and the resonant effects to remove passing α-particles [3].

For the helically trapped and passing non-resonant α-particles separated with the velocity phase space parameter $V_{\|}/(V_{\perp}\varepsilon_{eff}^{1/2})$ confinement time ratio τ_α/τ_E connected with the transport coefficients $D_{1/\nu}$ and $D_{plateua}$ is the following

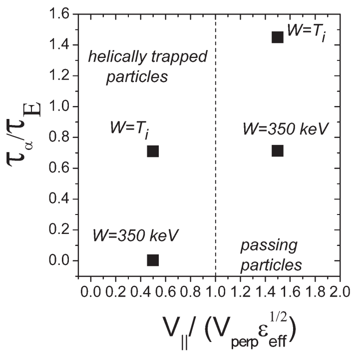


Fig.1. Confinement time ratio of cold α-particle and helium ash versus the parameter $V_{\|}/(V_{\perp}\varepsilon_{eff}^{1/2})$.

The resonance condition connects the "wave" numbers and frequency of the magnetic perturbation m_k, n_k, ω_k with the parallel velocity $V_{\|}$ and drift velocities V_{Dt} and V_E of the particles, magnetic rotational transform $\iota(r_0^2)$, major radius of the configuration R and minor radius of the magnetic surface r_0 as follows

$$\omega_k + m_k\left(\frac{V_{\|}}{R}\iota(r_0^2) - \frac{V_E}{r_0} + \frac{V_{Dt}}{r_0}\frac{1}{2}\right) - \quad (1)$$
$$- n_k\left(\frac{V_{\|}}{R} + \frac{V_E}{r_0}\left(\frac{r_0}{R}\right)^2\iota(r_0^2) - \frac{V_{Dt}}{r_0}\left(\frac{r_0}{R}\right)^2\iota(r_0^2)\frac{1}{2}\right) = 0$$

This resonance condition shows that the perturbations with the nearest to 10/10 numbers, namely 11/10 and 12/10, also can make their contribution to the drift resonances (Fig.2)

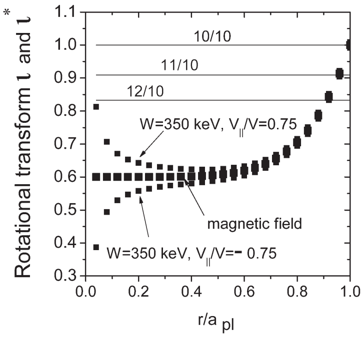
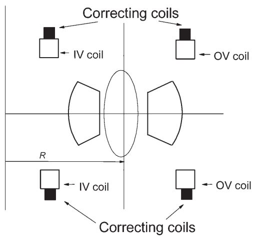


Fig.2. Resonance condition for the passing cold α-particles

The perturbations mentioned above can be caused with the "correcting coils" which complement the main vertical field coils (Fig.3).



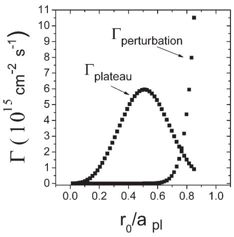


Fig.3. Layout of coils.

Fig.4. Fluxes of cold α-particles

Perturbations by correcting coils makes possible to control the cold α-particle fluxes $\Gamma_{plateau}$ and $\Gamma_{perturbation}$ (Fig.4), i.e. either to enlarge or to decrease the loading on the divertor plates.

1) Sagara, A. et al.: Nuclear Fusion **45** (2005) 258.
2) Shishkin, A.A. et al.: Fusion Engineering and Design **81** (2006) 2737.
3) Shishkin, A.A.: Nuclear Fusion **42** (2002) 344.