§12. Adiabatic Invariance Analysis of D^3He Fusion Products in an Axisymmetric Field Reversed Configuration

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Field reversed configuration (FRC) is a very attractive candidate as a low radioactivity D^3He fueled commercial fusion reactor. Since energy balance for such reactor is significantly determined by fusion products, we will study the motion of high energy fusion products in an axisymmetric FRC.
An appreciable fraction of particles in an FRC are stochastic [1]. Also, one can observe passing and trapped particles trajectories. Passing particles intersect the middle plane $z=0$ every bounce whereas trapped particles is confined in one-half of the system with $z>0$ or $z<0$ during a bounce. The presence of stochastic behavior in particle motion and availability of passing and trapped particles could be significant in distribution function calculations, diffusion and equilibrium studies.

Action integral around one gyro-oscillation would be appropriate for analyzing particles behavior in an FRC $J = \oint v_r dr$ [2].

It is an adiabatic invariant in the case of reactor magnetic field when gyro-frequency of particle oscillations exceeds much more than a bounce frequency. Numerical investigations of action integral - J are introduced. An availability of boundary values of J between stochastic and regular, passing and trapped particles is obtained. A simple analytical model of bounce oscillation was considered for the determination of boundary J. This model is based on averaging over gyro-period. The distinctive features of it is the conservation of J over a bounce.

Boundaries between particles populations as a function of angular momentum - P_θ and action integral - J have been investigated (fig.1). Those boundaries are considered in velocity space too. The analysis of boundaries allows us to estimate the part of fusion products that lost from the system immediately after their birth. Also stochastic/regular and trapped/passing fractions of particles could be calculated. This calculations was made for fusion protons under the assumption that the plasma density and temperature are almost constant along magnetic lines inside the separatrix.

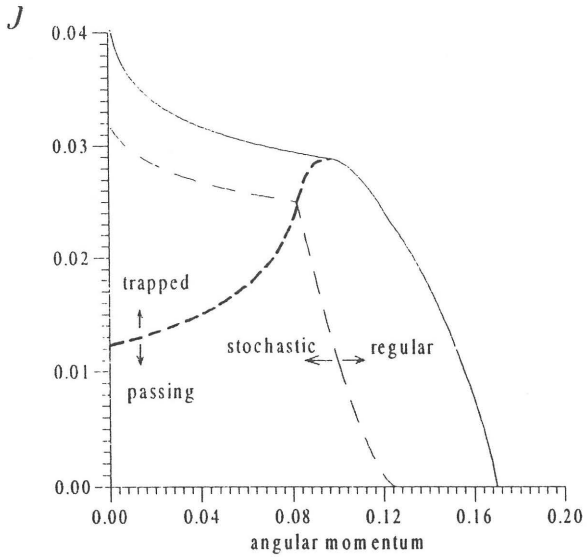

Fig. 1. The boundaries between main populations of fusion protons on dimensionless J-P_θ plane .

References

1) Finn J.M., Plasma Phys. 21 (1978) 405.
[2] Kim, J.-S., Cary, J.R., Phys. Fluids 26 (1983) 2161.