α - Particle and NBI - Ion Deposition in a Compact Spherical Torus due to Slowing Down

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The power, torque and current deposition of NBI (Neutral Beam Injection) ions (P_b=1MW, E_b=40-70keV) and the generated thermonuclear α - particles in a high field spherical tokamak (R/a=40/25, B_t=3T) is determined by slowing down processes and the orbit losses.

Therefore we investigate the particle orbits by Monte Carlo simulation (NFREYA) accounting for the Fokker - Planck equation. For the tracking of the orbits until completion of slowing down the guiding center equations are used.

Both, the full gyro and the guiding center description allow to estimate the first orbit losses of the α - particles, the generation of which depends on the profiles of the plasma parameters which are characterized by a peaking parameter p defined by $n=(f(r))^p$. A parabolic profile is assumed for f(r).

We find that the α-particle first (gyro) orbit containment is due to the large toroidal field around 0.4 for flat profiles ($p \approx 0.125$) and somewhat larger (20%) for peaked temperature and density profiles ($2 < p < 4$).

Repetitive pellet injection with a repetition time of 100 ms was assumed to increase the the peaking parameter of the density profile. With an effective pellet radius of 0.38 mm and a pellet speed of 3.2 km/sec an almost triangular ($p \approx 2$) density profile can be achieved.

Taking into account the slowing down processes due to the Fokker – Planck equation the power containment computed by guiding center tracking of the α particles is ≈ 0.3. Here each collision event effects new orbit parameters in particular at small pitch angles. At large pitch angles the counter - and co – orbits are rather stable.

The NBI deposition profiles of the current, torque and power show the expected energy dependence. The total driven current and the torque increase with increasing beam tangency radius R_b.

By means of the finite difference solution of the Fokker - Planck equation (obtained by the code NFIFPC) the distribution function of the fast ions and related quantities are computed.

These calculations e.g. yield a characteristic peak of the distribution function $f_{max}=5\ 10^{-8}$ $msec^3/cm^6$ in the co – region of velocity space and a driven current (73 kA for 1 MW α-power) which is comparable to the Monte - Carlo result.