Confinement of fast ions and FLR effects in presence of magnetic islands

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Fast ions are very important in many aspects of toroidal devices for plasma confinement. They appear mainly in relation to plasma heating from auxiliary sources such as NBI and ICRH where the injected energy is concentrated in a small population of energetic particles which have to transfer their energy to thermal particles by collisions. Fast ions have to be well confined before thermalizing in order to optimize heating. However, the presence of magnetic perturbations such as magnetic islands may increase the transport and reduce the confinement time which would reduce heating efficiency and produce energy waste. On the other hand, for moving perturbations, such as rotating magnetic islands, the associated poloidal flow may reduce the transport. For that reason it is of great interest to study the effect of magnetic islands on the transport of fast ions crossing the island region under different circumstances. Islands can be formed spontaneously by neoclassical tearing modes (NTM) or created from the outside by resonant magnetic perturbations.

We have initiated a study of transport of fast ions across the magnetic island region using both guiding center (GC) and full orbit (FO) computations. The goal is to determine how important the finite Larmor radius (FLR) effects are on the radial transport and figure out if resonant effects are relevant when this radius is of the order of the island width. The codes are validated by computing the transport coefficients and comparing with neoclassical computations. The simulations presented here consider a population of fast ions inside the radius of the rational surface that contains the island chain and measure the flux of crossing particles as they thermalize when collisions with a Maxwellian plasma background are included consisting of electrons and a single species of ions, which are described by Lorentz scattering.The equations of motion for each case (GC and FO) of a charged particle in a strong magnetic field are solved using an analytical model for the tokamak magnetic field and the magnetic island typical of a medium size tokamak. The initial particle distribution is monoenergetic and has a given pitch angle dispersion. The results of the GC and FO codes are compared in order to identify the differences ascribed to FLR. The presence of an electric field associated with the island itself resulting from the NTM is included, which leads to an increase in the particle flux beyond the one without the E-field, which indicates a predominance of the poloidal components of these fields. Island rotation is taken as a free parameter and we found a resonant-like effect where the flux is maximum when the rotation frequency is of the order of a characteristic particle frequency.