Method of Alfvén Wave Heating in Low Aspect Ratio Tokamaks

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Several experiments in low aspect ratio or spherical tokamaks (ST) produced in the last few years efficient plasma confinement in high beta regimes, and radio frequency (RF) plasma heating and current drive are considered important aspects of the experimental and theoretical programs in this configuration (see, for example, results from the NSTX experiment [NUCL FUSION **41** (2001) 1435], where fast wave heating and current drive was effectively produced). The ETE spherical tokamak that was recently put into operation in Brazil provides the possibility of performing experiments of auxiliary RF heating and current drive in the Alfvén frequency band. Accordingly, a two dimensional MHD code named ALTOK, which is designed for calculations of plasma heating due to radio frequency fields in the Alfvén and ion cyclotron range of frequencies (1-5MHz), is used to analyze Alfvén wave absorption for multispecies plasmas in axisymmetric ST configurations. The global and surface Alfvén (GA and SA) wave modes are found to be the best candidates for heating regimes in hydrogen plasmas in ETE. GA waves are efficiently excited by the antenna with $M=-1$ (poloidal) and $N=-2, -3, -4$ (toroidal) wave numbers in the hydrogen plasma. In plasmas with a helium minority, the GA wave is dissipated by the minority ions with cyclotron resonance located far from the magnetic axis. The SA wave (excited by the $M=+1;$ $N=2, \pm3, \pm4$ antenna) is effectively dissipated in the hydrogen plasma with a fully ionized carbon (or helium) minority component.

The design of the RF system for ETE is based on model experiments that have been carried out in the TCABR tokamak. The antenna system envisioned for ETE is composed of four antenna groups, which are separated by 90° in the toroidal direction. Each of the groups has four antenna loops: 2 above and 2 below the equatorial midplane of the torus. Their poloidal position is ± 45° with respect to the equatorial midplane. The toroidal spacing ≈22.5° is determined by the requirement of excitation of the traveling waves with $N= \pm2, \pm3, \pm4$. The antenna loops present a toroidal inclination designed to maximize the coupling efficiency and are isolated from the plasma by BN boxes. A four-phase RF generator powers the antennae with output power up to $P_{RF} \leq 1$MW through the impedance matching units.