§20. Impurity Transport Model for the Normal Confinement (NC) and High Density H-mode (HDH) Discharges in Wendelstein VII-AS

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An impurity transport model is proposed to explain the difference in the time evolution of AlXII (0.776nm), AlXI (55nm) and AlX (33.3nm) lines after the laser blow off of aluminum ions between the normal confinement (NC) discharges and the high density H-mode (HDH) discharges.

The high density H-mode (HDH) plasma is characterized by a good energy confinement with flat density profile and a reduction of impurities, confinement, compared to the normal confinement (NC) discharge with peaked density profile but almost comparable temperature profile. The reduction of impurity in the HDH plasma is clearly observed in the faster decay of impurity lines after laser blow off in the core (AlXII and AlXI) compared to the NC discharges. The faster decay time can be explained by a larger diffusion coefficient or smaller convective velocity.

When the mobility is given by the Einstein relation, the convective velocity is expressed as $v = D Z E_r / T_i$, which would be the case for collision frequencies much larger than the ion cyclotron frequency. In the magnetized plasma, the mobility becomes small because of the gyro-motion. In this model, the convection velocity is given by the radial electric field as v (m/s) = C_m x Z E_r(V/m)/ T_i (eV) with $C_m = 0.015$ both for NC and HDH discharges. The radial profiles of the radial electric field are derived by the electron density and temperature profiles assuming no bulk poloidal flow and $T_e = T_i$, i.e. $E_r = (1/en_e)(dP_e/dr)$. Since the HDH plasma has a flatter density profile than the NC plasma, the radial electric field in the core region in the HDH plasma is smaller than that in the NC plasma. Therefore the convective velocity, which is assumed to be proportional to the radial electric field, is also small in HDH plasma as seen in Fig.1. The large inward velocity at the plasma edge in the HDH is compensated by the large diffusive fluxes.

Figure 2 and 3 show the time evolution of the AlXII line measured and calculated using the MIST code with the diffusion coefficient and convective velocity plotted in Fig.1. There are good agreements between the measurements and the MIST calculation of AlXII, AlXI, AlX lines both in the NC and HDH discharges. These results suggest that the difference in the impurity decay time between NC and HDH discharges is due to the difference in the convective velocities, (and radial electric field profiles) not due to the difference in the diffusion coefficients.

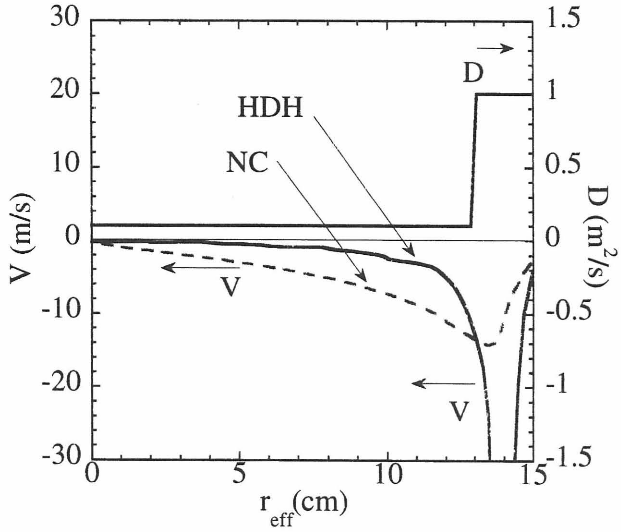

Fig.1 Radial profiles of convective velocity and diffusion coefficient for normal discharge (NC) and high density H-mode discharges (HDH).

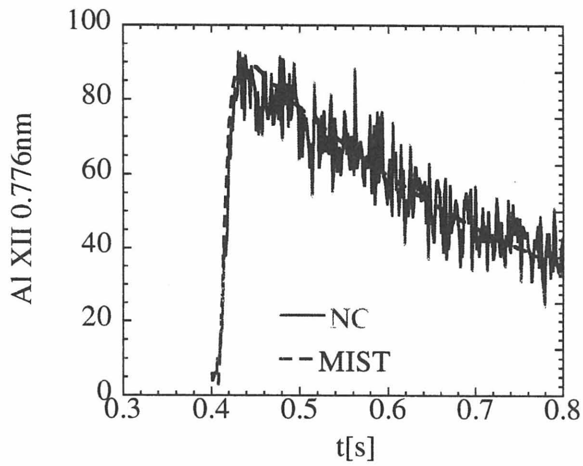

Fig.2 Time evolution of Al XII line for the normal confinement (NC) discharge.

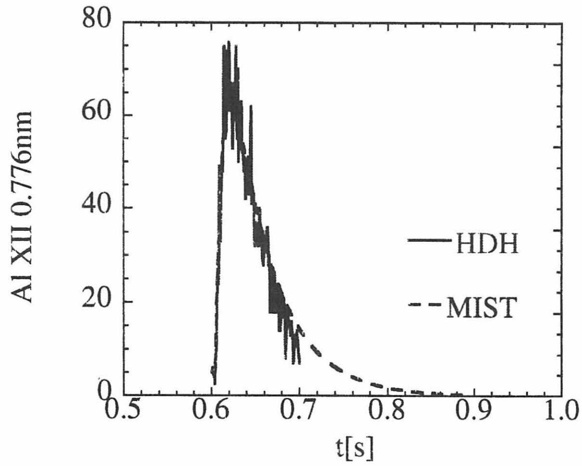

Fig.3 Time evolution of Al XII line for the high density H-mode (HDH) discharges.