§26. Primary Electron Orbits Calculation Code for Designing Ion Sources for NBI

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Spatial distribution of primary electrons emitted from cathode filaments are assumed to have much effects on the discharge characteristics of the ion sources.[1,2] Arcing and mode change of arc discharge are apt to occur in case of local trapping of primary electrons. Compared with positive ion sources, negative sources have less magnetic "field-free" region. So design of filaments' positions is especially important.

We have made a simulation code in which orbits of primary electrons are calculated including collisions with H_2 gas molecules to obtain spatial distribution of ionization points in the source. Each electron orbit between collisions are obtained by solving three dimensional equation of motion. We applied this code to designing filament positions of a negative hydrogen ion source for NBI#1 in LHD.

The arc chamber is a rectangular copper, 1400mm×350mm wide and 250mm deep. A pair of magnets are set to produce external magnetic filter field. The number of filament ports is twenty-four on the top wall and twenty-eight on the side wall. Two types of tungsten filaments(spiral and modified-V shape) are used, whose diameters are 2mm for spiral and 1.8mm for modified-V shape.

Primary electron orbits were calculated for two different cases. Fig.1(a) presents the cross-sectional view of the arc chamber where 20 spiral filaments are located in the top filament ports (CASE1). For CASE2, 24 modified-V shape filaments are situated in the side filament ports shown in Fig.2(a).In both cases 150 electrons were emitted from each filament. Figures 1(b) and 2(b) are the diagrams of obtained ionization points projected on the arc chamber cross section for each case. Closed rectangles denote ionization points in each figure. In CASE1, ionization points are localized in the triangle-like region including filaments. On the other hand, in CASE2, they are scattered almost uniform in the arc chamber except magnetic filter field region. We can estimate that discharge region gets wider in CASE2 than in CASE1. In our experiments, we confirmed drastic reduction of arcing frequency and extinction of mode change in CASE2 compared with in CASE1.

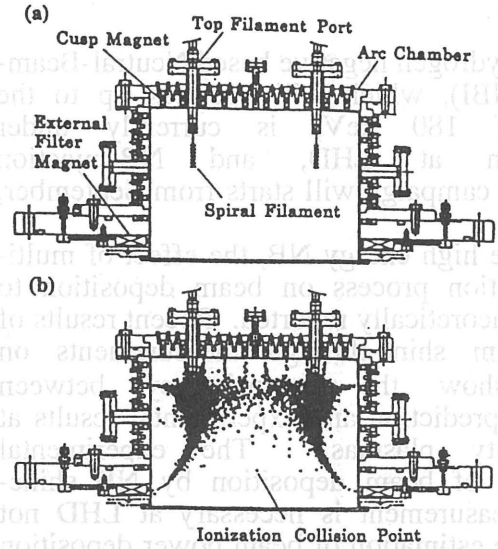

Fig.1 (a) Setup of simulation and experiment (cross-sectional view),(b) Distribution of ionization collision points for CASE1

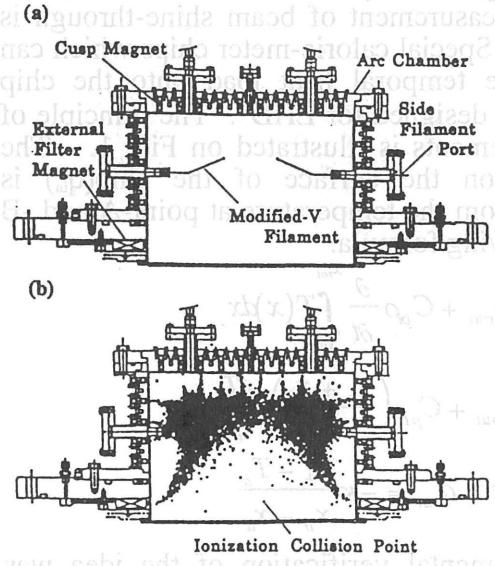

Fig.2 (a) Setup of simulation and experiment (cross-sectional view),(b) Distribution of ionization collision points for CASE2

1) S.Tanaka,et.al., Rev. Sci. Instrum.57 (2) , 145(1986)
2)O.Kaneko,et.al., Rev. Sci. Instrum. 57(1),67(1986)