## §10. Double-Layer Pellet for Diagnostics of Particle Transport

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An innovative method to measure particle transport both in parallel and in perpendicular to the magnetic field line for plasma confinement is proposed. The essential point is based upon the poloidally and toroidally localized particle source as a tracer. This can be realized with a double layer pellet which consists of small core as tracer such as lithium and the major outer layer of hydrogen or deuterium which is the same species as the bulk plasma. The relation between location of tracer particle deposition in the plasma and pellet size (or disturbance to the target plasma) is also shown with a parameter of pellet velocity. The results indicate that the method seems promising.

The transport phenomena are complicated, and the direct measurement about transport is very few. For example, a laser blow-off method has been used so far to study particle transport of impurities. In this method, the "blow-off" impurities enter into the plasma through the plasma scrape-off layer. Thus, it is almost impossible to know the precise amount of the impurities entering inside the outermost surface of the plasma. Moreover, it is difficult to localize the impurity source with width of order of 1 cm (even in the initial phase) inside the plasma. Then, quantitative analysis is rather complicated, although qualitative observation of impurity transport is possible.

Therefore, the physics of transport of particle and energy is still to be clarified. Taking account of this situation, a new method to measure particle transport both in parallel and in perpendicular to the magnetic field line is proposed in this article.

The essential point of this method is based upon the poloidally and toroidally localized particle source as a tracer which is confined originally within a limited small volume with order of about 1 cm$^3$. After injection of a double layer pellet into a plasma, the locally deposited 'tracer' particles (originated from the core of the double layer pellet) in a plasma are immediately ionized and heated by the bulk electrons and ions. These tracer particles move along field lines at first. Such motion in the parallel to the magnetic field lines may be detected with the following methods: (a) a multi-channel soft-X array, (b) a bremsstrahlung detector array, (c) a charge exchange recombination spectroscopy (CXRS) array with high time and space resolution at the location of neutral beam (for diagnostics or heating).

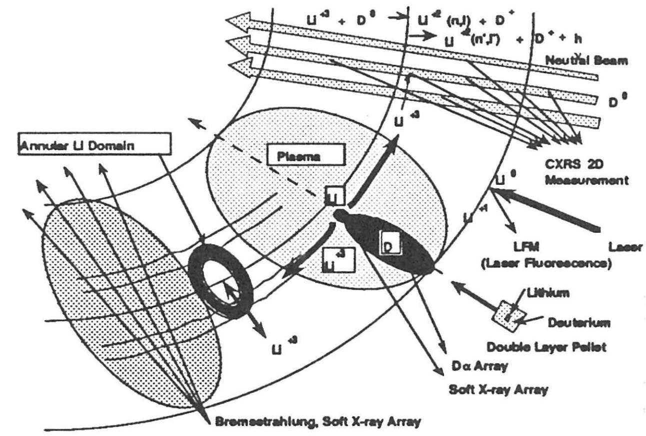


Fig. 1. Principle of Diagnostics by Double-Layer Pellet

The local deposition of tracer particles can be realized with a double layer pellet as shown in Fig. 1. It consists of small core as tracer of light atom such as lithium and the major outer layer of hydrogen or deuterium which is the same species as the bulk plasma. This might seem to resemble the usual impurity pellet injection or laser blow-off method. The essential difference, however, is in the very clear localization of tracer particles. This feature makes the transport in the parallel to the magnetic field line clear in the initial phase, which is not possible by the above two methods. And, this can simultaneously make diagnostics about radial transport much clearer because of radially narrow localized tracer particles than the other two methods. Furthermore, with the proposed method, the amount of the deposited particles are clearly identified because of known pellet size of the inner core of the double layer pellet.

The disadvantage of the proposed method is the disturbance to the target plasma mainly caused by particle deposition due to pellet. The smaller pellet is desirable from the viewpoint of minimizing the disturbance. In other hands, for depositing tracer particles in the plasma core region, the larger pellet is necessary so that the pellet may penetrate deep into the plasma. Therefore, some trade-off is necessary. The tolerable level of the disturbance may be different depending on the concerned phenomenon. Here, relation between degree of disturbance to the plasma (increasing ratio of plasma particles) and depositing location of the tracer particles in the plasma core region is studied, and it will be shown that the reasonable operation range exits. When the location of the tracers is aimed in the region of half radius or more outer side, the disturbance will be reduced more because a smaller pellet is usable. This would be still useful for transport measurement in the plasma edge or divertor region.