§ 39. Relationship between Magnetic Field Structure and Plasma Density Profile in LHD Local Island Divertor

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The LID(Local Island Divertor) is proposed to control the edge plasma in LHD(Large Helical Device). Since this method uses a large m/n=1/1 island, which is produced artificially with external LID coils, the magnetic structure of the so-called separatrix layer or edge region in LHD is expected to be affected largely. Though MHD equilibrium theory gives us a theoretical background on magnetic surfaces in the main plasma region, we have no measure to quantify the magnetic structure of the separatrix layer yet.

In order to measure the edge plasma density profile in LHD, a Li-beam probe system was installed to the port 4.0 before the 6th experimental campaign. Its beam path, however, does not lay on the poloidal cross section of LHD (see. Fig. 1.), so some modification of magnetic field line tracing code such as KMAGN is needed in order to compare with density profile data. Moreover, we must be careful to calculate in LID experiment case, since the helical symmetry is broken with the LID coil field. One example of the Poincaré map of Li-beam propagating surface is shown in Fig. 2. The m/n=1/1 island is produced with the LID coil current 1600[A]. The holizontal line at $Z = 0.3$[m] indicates the Li-beam path, which crosses the LID(m/n=1/1) island at its edge region. So the information at the center of this island (the blank region around $R = 4.3$[m] and $Z = 0$[m]) can not be available. In Fig. 2, we can observe small satellite islands around the LID island. This is the evidence of the self-similarity of chaotic magnetic field lines.

One of most promising tools for studying the chaos is the Lyapunov exponents of the reconstructed attractor. Though various algorithm to calculate the Lyapunov exponents have been proposed, Wolf's method, which counts the expansion of the distance between the reference orbit in the phase space and neighborhood point, is the most convenient to use. About 1000 step data usually allow the maximum Lyapunov exponent(λ_1) to converge to a constant value. In Fig. 3, the estimated λ_1 are plotted with a solid line for the field lines of Fig. 2 . As a reference, λ_1 for the case of LID coil current of 800[A] are also plotted with a dotted line. The horizontal axis is major radius of starting points, which are set along Li-beam path and shown with small symbols ($\times$) in Fig. 2. As you can see, there exist a little chaotic boundary between the LID island and regular magnetic surface. Moreover, the last closed surface becomes smaller with the LID coil current.

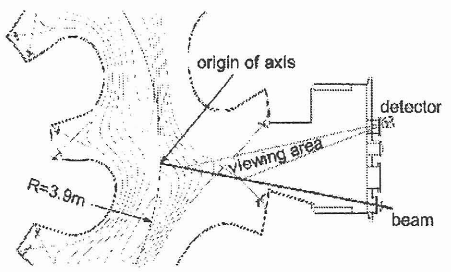

Fig. 1: The setting of Li-beam probe system.

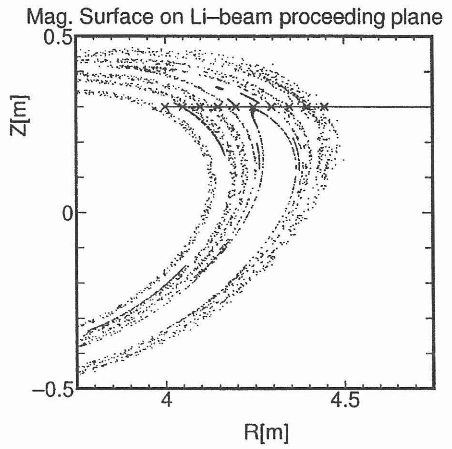

Fig. 2: The Poincaré map of Li-beam propagating surface. The m/n=1/1 island is produced with the LID coil current 1600[A].

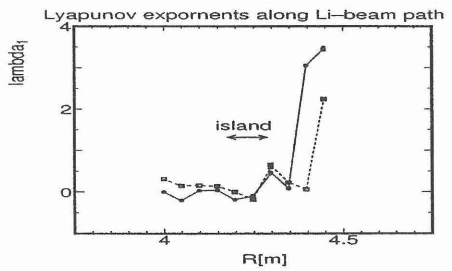

Fig. 3: The Lyapunov exponent of field lines along Li-beam path. A solid line is the case of the LID coil current of 1600[A] and a dotted line is for 800[A].

References

[1] Morisaki T., et al.: 27th EPS ECA **24B**, **(2000) 780.**