§31. Design Study of a Dispersion Interferometer on Heliotron J

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The electron density is one of indispensable parameters not only for physical analysis but also for fueling control. A heterodyne interferometry is a main density measurement method at present fusion devices. However, there are two disadvantages. One is measurement errors due to mechanical vibrations and the other is fringe jump errors in a high density range. These days, the electron density in Heliotron J is increasing by SMBI and configuration with low toloidicity. Hence, the density measurement method which can be used with high resolutions and high reliability even in the high density range is required. A dispersion interferometer can compensate the mechanical vibration by itself [1] and the vibration isolation system are not necessary.

The original plan is to use the existing high power CO_2 laser which was used for phase contrast imaging on Heliotron E. However, there was a problem in DC discharge and it was not available. Hence design study is conducted with a commercial CO_2 laser.

One of key issues of the dispersion interferometer is the power of the second harmonics generated with a nonlinear crystal. While the CO_2 laser with a power of 8W is used on LHD [2], we examined availability of a low power laser with a power of 1 W, which has a cost advantage. Figure 1 shows the second harmonic power. The laser is expected to be L4S of Access Laser Co. This laser has air cooling system, and then the measurement system becomes simple because a chiller system, which is expensive, is not necessary. The nonlinear crystal is $AgGaSe_2$, which is embraced by the dispersion interferometer on LHD [2]. The generation efficiency is proportional to the square of the incident laser power. On the other hand, there is the upper limit of the injection power. This is because that the thermal lens effect causes the degradation of the generation efficiency due to absorption of the laser power. Although the damage threshold of the crystal is 33 kW/cm^2, it is reported that the thermal lens effect occurs for lager power than 2 kW/cm^2. The radius of the laser beam at the crystal should be larger than 0.18 mm to avoid the thermal lens effect. The Rayleigh length, which is a length to be identified as a parallel light, is 50 mm. This is longer than commercial $AgGaSe_2$ ~ 15 mm. In this design, the available second harmonic power is 26 μW. This is almost the half of that of the dispersion interferometer on LHD. This power will provide an interference power with an amplitude of larger than 3 V, even allowing decreases of the power at a vacuum window and in-vessel mirrors.

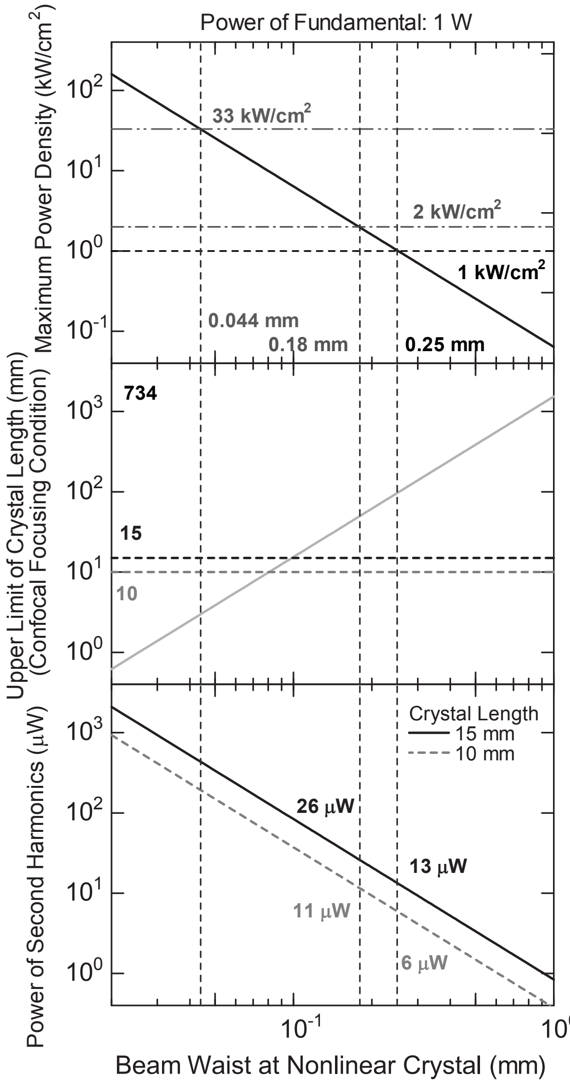

Fig. 1: Second harmonic generation with a CO_2 laser with a power of 1 W and a nonlinear crystal $AgGaSe_2$.

From these considerations, it is fond that a commercial low power CO_2 laser can be a candidate of a laser source of the dispersion interferometer on Heliotron J.

1) P. A. Bagryansky *et. al.*, Rev. Sci. Instrum. **77**, 053501 (2006).
2) T. Akiyama *et. al.*, Rev. Sci. Instrum. **85**, 11D301 (2014).