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Top-B project; Experimental research to generate 10Mgauss Ultra-High magnetic field

Top-Bプロジェクト
10Mgauss級超強磁場発生実験

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Generation of several 1000T magnetic field can be applicable to the new physical study. That magnetic field can generate dense magnetized plasma, it can also be applicable to the study of magnetic reconnection. The previous method to generate strong magnetic field was used cylinder with seed field compressed by electromagnetic force, it could generate about 600T. This experiment aspire for stronger magnetic field with laser-ablation pressure. We achieved measurement Faraday-rotation of generated magnetic field compressed by laser-ablation.

In some methods of generation of ultra-high magnetic field, using laser-ablation pressure is focused for applicability for other physical study. In this experiment, we used G-XII laser in Osaka University as ablation power.

The compression target is made of 3 parts; stainless steel bulk, acceleration foil, and empty space[Fig.1]. First, seed magnetic field generated by coil with pulse power device. Then ablation laser exposed, seed magnetic field is compressed to strong as inverse proportion to empty space.

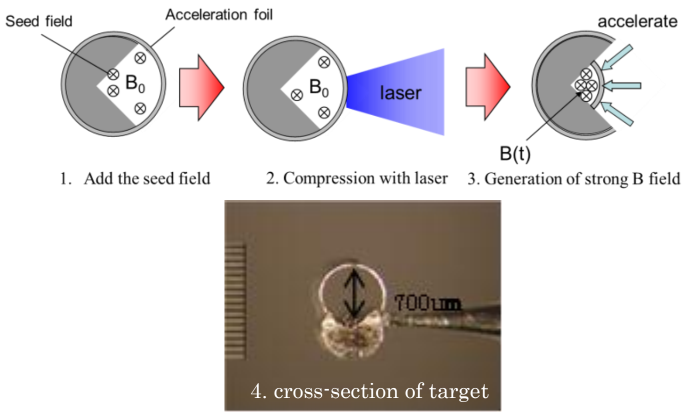

Fig. 1 Generation process of ultra-high magnetic field.
(1)add the seed magnetic field by coil.
(2)compress the target with laser.
(3)accelerate foil and generate strong magnetic field.
(4)cross section of target.

In empty space, grass fiber is put on for measurement of magnetic field. In magnetic field, polarization of lights rotates by Faraday Effect. We can estimate amplitude of magnetic field by measure polarization angle θ of prove lights. V is Verde constant, depends on materials. Verde constant of fiberglass is 0.0195[min/Oe・cm] in 546nm prove light wavelength. H is the amplitude of magnetic fields, and L is the length of medium.

$$\theta = VHL$$

In the past, it has been found that empty space is compressed by laser-ablation, but radiation from the acceleration foil block the prove light[Fig.2]. In order to solve the problem, we put a foil around the fiberglass, protect from the radiation. We tried some different material (Au, Ti, Cr, Al) combination of acceleration foil and protection foil.

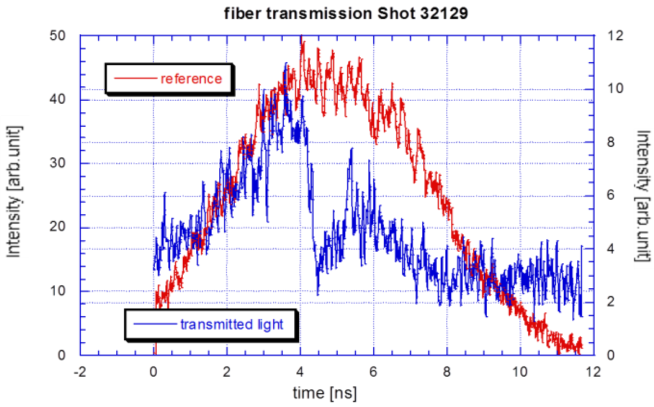

Fig.2 Prove light intensity without fiber protection

Then, compression aspect by laser-ablation is shown in Fig.3. Empty area of the target is compressed between initial position of accelerate foil and t~1ns. Comparing compressed area to non-compressed one, area width became to about one-third. It means seed field increase threefold strength.

Measurement of Faraday rotation result is shown in Fig.4. In this experiment, target expose spot size is 0.5mm. If polarization rotates 360 degree, magnetic field amplitude will be 2102T. Then right side of Fig.4 shows intensity ratio of two polarization of transmitted prove light. The largest rotate point, intensity ratio was 0.4 at 4ns. In this case, rotation angle is estimated by considering

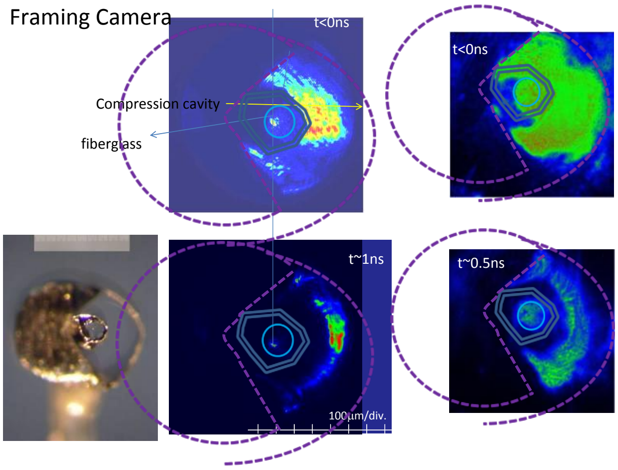

Fig.3 Cavity compression

rotate over 90 degree at 1.6ns, as 140 degrees, correspond to 817T. If seed magnetic field strength was 20T, empty space in the target is supposed to be compressed >40 times. For that compression

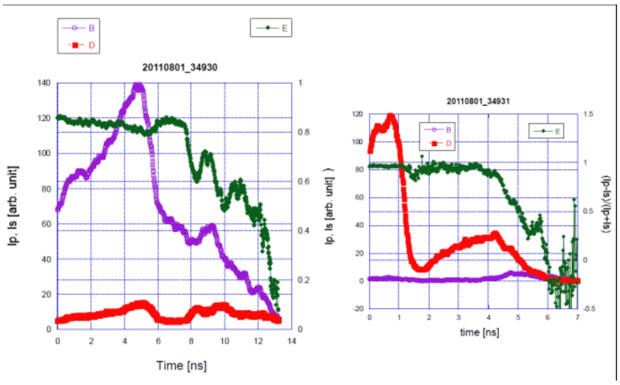

Fig.4 amplitude of transmitted prove

ratio, radius of the target is 1/6.4. Initial radius of target was 0.77mm, compressed target radius would be 0.12mm, it shows accelerate foil was pressed going to fiberglass.

In summary, it was shown that using laser-ablation pressure, seed magnetic field can be compressed and generate strong magnetic field. That strong magnetic field can be estimated by measuring Faraday rotation of prove light. That magnetic field strength can be up to several hundred teslas, can make magnetized plasma.

It is challenge to the future increasing compression rate and exact measurement of ultra-high magnetic fields. To solve the problem, we have to estimate the length of medium in Faraday rotation equation.

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