新しい高速集光用プラズマミラーの開発

Development of Plasma Mirror as Advanced Fast Optics

Objective

プラズマミラーは、従来の固体光学素子に比べ 100 倍以上の高い強度の光を制御できる。パワーレーザーなど比較的大型の装置においては、ワーキングディスタンス等の制約から小さな F 値の集光は困難であった。これに対してプラズマミラーは従来に比べ桁違いに小さな素子が可能となり、幾何学的配置に対する制約から解放され、これまで不可能であった極限状態での光制御 [1]が可能となる。その 1 つとして高速集光用のプラズマミラーの開発を行っている。

Achievement

- 回転楕円体を利用した高速集光幾何学配置により、高精度で集光用プラズマミラー設置精度が可能となり、従来困難であった高速集光をパワーレーザーシステムで実現した。[2] (Fig. 1)。
- 本デバイスにより高効率に超高強度場を実現し、従来に比べ 5 倍以上高いエネルギーのプロトンビーム発生に成功した [2] (Fig. 2)。
- この高速集光素子により、7 桁以上高い効率で真空非線形光学現象を実現する幾何学配置が可能となる [3]。

One of the advantages of plasma mirrors is control of intense light higher than that with conventional optics by 2 orders or more. Fast focusing had been difficult of high power laser light. However, the plasma mirror, which was much smaller than conventional optics, would be free from the geometrical-optics limitation. Consequently, we are developing a plasma mirror as fast focusing optics with f/# of less than 1.

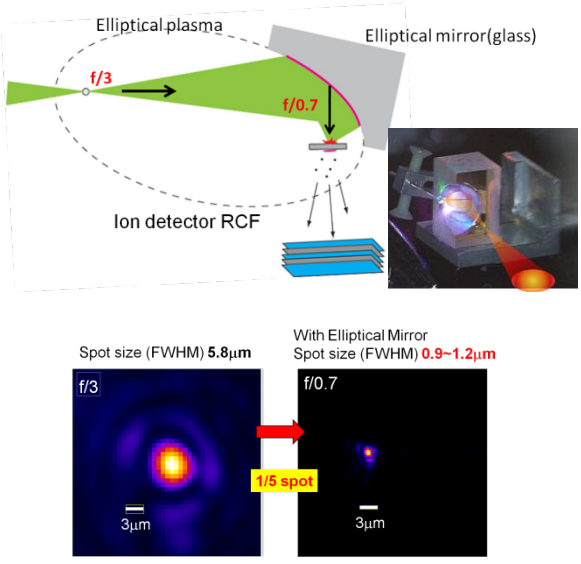

Fig. 1: Geometrical optics of plasma focusing mirror with a spheroid. f/#<1 has been achieved with this plasma device and the focal spot diameter of less than a few μm has been realized in a large facility of high power laser systems.

• Alignment of focusing plasma mirror had been one of key issues to be used for fast focusing in large power laser systems. Using a shape of spheroid as a plasma mirror has realized fast focusing of laser light in the large system for the first time.
• The maximum energy of proton beam, generated in relativistic laser-plasma interaction with this plasma mirror, has been enhanced by a factor of 5 or more as compared with the conventional focusing. (Fig. 2)
• Nonlinear optical phenomena in vacuum could be also realized with the fast focusing optics, resulting in the enhancement by 7 orders of magnitude.

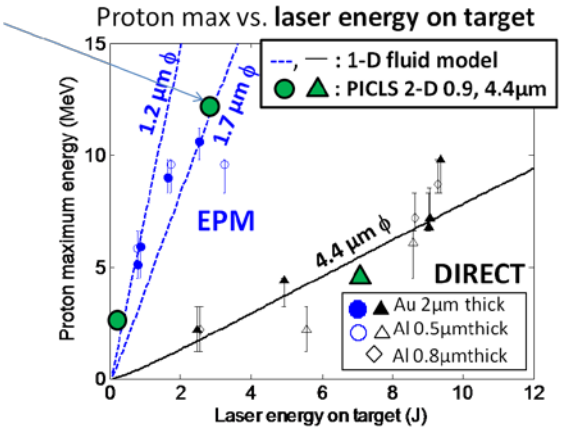

Fig. 2: Proton maximum energies as a function laser energy on target for different focusing optics: circles are obtained with the plasma mirror and triangles with conventional optics. Green points are given by 2-D PIC simulations.

Reference

1) R. Kodama et al. : "Fast heating of ultrahigh-density plasma as a step towards laser fusion ignition" Nature 412, 798 (2001)
2) M. Nakatsutsumi et al: "Fast focusing of short-pulse lasers by plasma optics toward extreme intensity" Opt. Letts. 35, 2314 (2010).
3) Y. Monden and R. Kodama: "Enhancement of laser int. with vacuum for a large angular aperture" Phys. Rev. Letts. (2011 in press)