3rd Asia-Pacific Conference on Plasma Physics, 4-8,11.2019, Hefei, China

Laser-plasma interaction in overdense plasmas under strong magnetic fields

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The interaction of dense plasmas with an intense laser under a strong external magnetic field has been investigated. When the cyclotron frequency for the ambient magnetic field is higher than the laser frequency, the laser's electromagnetic field is converted to the whistler mode that propagates along the field line. Because of the nature of the whistler wave, the laser light penetrates into dense plasmas with no cutoff density, and produces superthermal electrons through cyclotron resonance. It is found that the cyclotron resonance absorption occurs effectively under the broadened conditions, or a wider range of the external field, which is caused by the presence of relativistic electrons accelerated by the laser field [1]. The upper limit of the ambient field for the resonance increases in proportion to the square root of the relativistic laser intensity. The propagation of a large-amplitude whistler wave could raise the possibility for plasma heating and particle acceleration deep inside dense plasmas.

Efficient plasma heating by electromagnetic waves has been demanded especially in laboratory fusion science. A serious problem is that most of the field energy is converted easily to electrons, but not to ions. We propose a novel heating mechanism for ions in overdense plasmas by introducing two whistler waves along a strong magnetic field in the counter configuration [2]. The essential process is the collapse of standing whistler waves within a short timescale comparable to the wave oscillation period. During the collapse, ions are accelerated by a static electric field and acquire a large amount of energy directly from the electromagnetic waves. Thermalized ion temperature reaches up to the order of 100 keV, which have turned out to be predictable theoretically from the initial wave-plasma conditions. This ion-heating mechanism could be applicable to an alternative future scheme of laser fusion as well as to various plasma phenomena such as magnetic confinement fusion and planetary magnetosphere.

References

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