講演番号をこちらに

23Ap01

Observation of Zeeman splitting effect in a laser-driven coil

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本　文

Zeeman effect is one of the most significant discoveries in 19th century. It has been applied in various active research fields since observed firstly in 1896. In atomic and molecular physics, Zeeman effect plays a key role in calculating atomic hyperfine structure. In material science, for example, the observed Zeeman splitting and oscillator strengths demonstrate the symmetry and fine crystal structure of Cr-doped GaAs. In fusion researches, it is used not only to measure the magnetic field (B-field) strength, but also to study the impurity particle transport in a magnetically confined fusion plasma through determination of line positions, shapes and hence species temperatures. In astrophysics, Zeeman effects make it possible to infer the B-field strength in remote varied objects with telescopes. It is very helpful to understand the evolution of these objects and some related astrophysical phenomenon, such as jets and magnetic reconnections. In laser-plasma researches, Zeeman effect is a powerful tool to measure strong B-field strength at local plasma position.

Here, we proposed the first observation of Zeeman splitting effect in a strong magnetic field generated with a laser-driven coil. The expanding plasma from the coil wire surface concentrated to the center and interacted with the simultaneously generated magnetic field. The Cu I spectral lines at a wavelength of 510.5541 nm, 515.3235 nm and 521.8202 nm have been detected and analyzed in this research. From the splitting of spectral lines, the magnetic field strength at the coil center was estimated to be 31.4 ± 15.7 T at a laser intensity of 5.6×10^{15} W/cm^2, which agreed well with the B-dot measurements. Some other plasma parameters of the central plasma disk have also been studied. The temperature was evaluated from Cu I spectral line intensity ratio, while the electron density was estimated due to the stark broadening effect.