Experimental measurements and an improved theoretical description of magneto-optical signals of the cesium D_1 transition in an extremely thin cell

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The extremely thin cell (ETC) is characterized by walls that are separated by a distance that varies from few hundred nanometres to approximately 1 μm [1]. Obtaining and modelling theoretically magneto-optical signals in an ETC presents various challenges. Previous attempts to model the experimental signals obtained good agreement between experiment and theory for rather narrow magnetic field scans. However, satisfactory agreement could not be achieved for larger magnetic field values [2]. In order to improve the theoretical model, we have expanded it to account for effects associated with particles flying through the laser beam in a much more refined way. The laser beam profile was split into multiple sections, each of which had its own characteristic laser beam intensity and transit relaxation rate. This approach allowed us to treat the wings of the laser beam profile, where the laser intensity is much lower than in the centre of the beam. Furthermore, a new approach to atom-wall collisions was applied by averaging over different velocity groups for the velocity in the direction perpendicular to the cell walls. To test the new features of the theoretical model in detail we chose the Cs D1 line, for which magneto-optical resonances have not been studied in an ETC, and which provides a simple system to test the physical effects that take place in this type of cell.

Magneto-optical signals were observed in fluorescence from one side of the ETC. The detector collected fluorescence light emitted in a direction that was nearly perpendicular to the laser beam. Although the fluorescence signal is weak, it is easier to separate it from the background, and its intensity is less subject to the interference effects that result from the etalon formed by the ETC walls and that are pronounced in absorption signals. The ETC was placed at the centre of a three-axis Helmholtz coil system. Two pairs of coils were used to compensate the earth's magnetic field, and the third coil was used to scan the magnetic field from -55G to 55G. To achieve detectable signals, the ETC was placed in small oven that was built in such a way that it practically produced no stray magnetic fields. To gain insight into processes within the ETC and to test the model, we measured the dependence of the signal on temperature, laser power, and cell thickness for different transitions. The experimental results were compared to theoretical calculations.

This work was supported by Latvian Science Council grant 119/2012.

References

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