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ΤΜΗΜΑ ΕΠΙΣΤΗΜΗΣ ΚΑΙ ΤΕΧΝΟΛΟΓΙΑΣ ΥΛΙΚΩΝ

ΠΑΡΟΥΣΙΑΣΗ ΜΕΤΑΠΤΥΧΙΑΚΟΥ ΔΙΠΛΩΜΑΤΟΣ ΕΙΔΙΚΕΥΣΗΣ

Τίτλος

«Imaging Systems for Ultra-low Optical Density Atom Clouds»

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This master thesis focuses on the optimization of optical systems that image ultra-cold and quantum degenerate atomic cloud (including Bose-Einstein condensates). Two independent optical systems, exploiting different imaging approaches, were designed and tested both in the optical and in the opto-mechanical level. The first optical system employs absorption and fluorescence imaging of small cold atomic clouds, while the second uses an innovative, non-destructive method, based on Faraday's non-destructive optical rotation, capable of measuring the number of atoms in an ultra-cold atomic cloud. A main goal of the thesis was to extend the resolution and field of view of such optical systems. In this perspective, various optical design techniques are analyzed taking into account optical aberrations by the various components of the experimental device. An important result of this analysis was the introduction of a novel, and counterintuitive, analytic optical design approach, where a flat glass plate can be used to cancel out the spherical aberrations introduced by the glass windows used to optically access the of the vacuum cell where BECs are generated. The optical design and optimization process was performed by using commercial raytracing software (ZEMAX). The opto-mechanical design was performed using CAD software (Inventor Autodesk).

The optimized optical systems were designed to use commercially available optical components. The first system exhibits excellent diffraction-limited optical performance at the maximal possible photon collection efficiency for the specific experimental configuration. The second optical system is designed to optimally extract the atom number information from the cloud, by optimizing the light-atom Faraday interaction and recording with minimal losses the probe light.