Development of quantum sensors for precision positioning and underground mapping

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Assunto(s): Interferometria Gravimetria

Resumo

We propose to initiate collaboration between the Instituto de Física de São Carlos of the Universidade de São Paulo and the Midland Ultracold Atom Research Centre (MUARC) of the Universities of Birmingham and Nottingham. The initial work, undertaken over a period of two years, will focus on developing a new type of quantum sensor based on laser-cooled atoms, capable of simultaneously measuring time and elevation, and detecting variations in density hidden below ground. The collaboration exploits the convergence of active research interests at the three institutions, supported by (1) off-site training and work exchange; (2) sharing of world-leading facilities and expertise; and (3) knowledge transfer and educational workshops. Motivation and innovation goals. Atom interferometric sensors and frequency standards based on ultracold atoms (Nobel Prizes in Physics: 1997, 2001, and 2005) have shown unprecedented precision for time-frequency, gravity and magnetic field measurements in laboratories. However, when it comes to applying this technology, there is a bottleneck associated with the size and complexity of existing experiments. We aim to make quantum technology practical, with novel dual-use sensors for time-frequency and gravitational metrologies. This type of sensor has the potential to revolutionize applications in oil and mineral exploration, navigation, climate research, and telecommunications. Our project brings together the complementary strengths and interests of multiple UK and Brazilian partners to develop a world-leading and long-lived collaboration. Expected results: The gravity sensor representing the basis of this project incorporates two unique features: It is the first dual-function sensor and the first to operate in a regime dominated by quantum mechanical interactions between light and matter. This allows self-calibration as well as continuous high-bandwidth measurements of the sensor output, and is expected to open completely new fundamental questions and research opportunities. We will combine the Birmingham and Nottingham capabilities in atom interferometry and precision frequency standards with expertise in atom-ring-cavity systems from the Brazilian partners in order to develop the world's first combined optical clock and gravity sensor. (AU)