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Penning mass spectrometry using optical detection with 40Ca+ as sensor ion in an unbalanced crystal

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A Penning mass spectrometry technique based on optical detection is under development in the University of Granada [1]. This technique is universal, non-destructive, and single ion-sensitive. The scattered photons by a $^{40}Ca^{+}$ ion will be used to measure the normal mode eigenfrequencies of the unbalanced crystal formed by this ion and the target one [2]. The dynamics of the two-ion crystal has been already studied, including the quantification of frequency shifts due to the Coulomb repulsion. Experimentally, the magnetic field of the Penning trap is the largest ever-used in laser-cooling experiments, which together with the level structure of the calcium ion, makes the cooling challenging. So far, Doppler cooling of small clouds in all the degrees of freedom has been demonstrated. However, residual pressure in the trap area prevents single ion sensitivity. In this contribution, we will describe the TRAPSENSOR facility, the results obtained so far, and the expected performance of the single-ion as sensor in the 7-tesla magnetic field. Also, we will present results regarding the detection of induced image currents using a new amplifier circuit developed by the group in collaboration with the University of Mainz (Block's group) and the company Seven Solutions and, for the first time in the field, using quartz crystal as resonant element [3]. We will end underlining the changes in our setup in order to develop a cryogenic Penning trap.

[1] M. J. Gutiérrez et al., *New J. Phys.* **21**, 023023 (2019)
[2] M. J. Gutiérrez et al., *arXiv:1907.08045* (2019)
[3] S. Lohse et al., *Rev. Sci. Instrum.* **90**, 063202 (2019)

Primary authors: Mr BERROCAL SÁNCHEZ, Joaquín (Universidad de Granada); Mr GUTIÉRREZ TORRES, Manuel Jesús (Universidad de Granada); Mr DOMÍNGUEZ GONZÁLEZ, Francisco (Universidad de Granada); Prof. RODRÍGUEZ RUBIALES, Daniel (Universidad de Granada)

Presenter: Mr BERROCAL SÁNCHEZ, Joaquín (Universidad de Granada)

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