

Long Term Evolution of Key Physical Parameters in Atomic Fountain Frequency Standards

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The role of atomic fountains in time and frequency metrology has grown along the last years with more and more demanding long term applications. These include providing high accuracy to TAI, and more recently to local timescales such as the UTCs^{1,2,3}, not to forget the future role as ground segment of the ACES/PHARAO mission or applications in fundamental physics such as the search for variations of constants⁴. Therefore a long term reliable fountain operation has become a real concern. Over the last 5 years, the LNE-SYRTE atomic fountain ensemble⁵ has been a major contributor to TAI with 3 participating primary frequency standards, FO2-Cs, FO1 and FOM. Also, FO2-Rb, the Rb part of FO2 was used to calibrate and steer the TAI frequency, using for the first time an atomic transition other the Cs hyperfine transition defining the SI second⁶. This prefigures the future participation to TAI of other secondary representations of the second based on optical transitions. For these applications, we have accumulated continuous data which gives us the opportunity to make a long term analysis of key physical parameters. We present this analysis over the last 4 years concerning, among other parameters, the static magnetic field, atom density ratio or verticality of the atom trajectory, which are central to establishing a reliable uncertainty budget of the fountain accuracy.

¹ A. Bauch, *et al.*, “Generation of UTC(PTB) as a fountain-clock based time scale”, *Metrologia*, 49, 180-188, 2012.

² S. Peil, *et al.*, “An ensemble of atomic fountains”, *Frequency Control Symposium (FCS)*, 2012 IEEE International, 1-4, 2012.

³ M. Abgrall, *et al.*, “Performances of UTC(OP) based on LNE-SYRTE atomic fountains”, submitted at this EFTF.

⁴ J. Guéna, *et al.*, “Improved Tests of Local Position Invariance Using 87Rb and 133Cs Fountains”, *Phys. Rev. Lett.*, 109, 080801, 2012.

⁵ J. Guéna, *et al.*, “Progress in atomic fountains at LNE-SYRTE”, *IEEE Trans. Ultrason. Ferroelectr. Freq. Control*, 59 (.3), 391-410, 2012.

⁶ J. Guéna, *et al.*, “Contributing to TAI with a secondary representation of the SI second”, *Metrologia*, 51, 108-120, 2014.