Stability of an optical frequency standard based on the 674 nm "clock" transition in $^{88}Sr^{+}$

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Optical frequency standards based on transitions in laser cooled trapped ions offer significant advantages over more established optical frequency standards [1]. We report here on the development at the UK National Physical Laboratory of a standard based on the 674 nm $^2S_{1/2}$-$^2D_{5/2}$ "clock" transition in $^{88}Sr^{+}$ [2]. Two trap systems have been built and the Zeeman components of the clock transition multiplet have been studied. Using a diode laser narrowed using an ultra-low-expansion high-finesse cavity, Zeeman component linewidths of less than 300 Hz have been observed.

The relative frequency stability of 674 nm probe laser radiation locked to single Zeeman features in two ions, trapped in two independent traps, was determined to be in the region of 100 Hz for averaging times of a few tens of seconds. These comparisons are ultimately limited by magnetic field fluctuations since all the components suffer from a first order Zeeman shift in the even isotope of $^{88}Sr^{+}$. To avoid this problem, an algorithm has been developed to control the frequency of the probe laser radiation relative to the centre of the Zeeman multiplet, by locking to pairs of components which are symmetrically placed about the line centre. Preliminary measurements of the relative stability of the centre frequencies of pairs of components in two ions trapped in two separate traps yield Allan deviations of less than 50 Hz over 30 second averaging times.

The odd isotope of strontium offers the possibility of a "clock" transition independent of the first order Zeeman shift and a scheme to cool and interrogate the ion using polarisation dependent optical pumping has been described recently [3]. A $^{87}Sr^{+}$ ion trap has been constructed. Laser cooling requires two cooling radiations (at 422 nm) separated by the ground state hyperfine splitting of 5 GHz. Fluorescence from trapped $^{87}Sr^{+}$ ions has been observed and trapping of single $^{87}Sr^{+}$ ions has recently been confirmed by the observation of quantum jumps induced by 674 nm radiation.

[1] Alan A. Madej and John E. Bernard "Single Ion Optical Frequency Standards and Measurement of their absolute optical frequency" in Topics in Applied Physics, ed. A. Luiten (Springer) to be published.

[2] G.P. Barwood, P. Gill, G. Huang and H.A. Klein, Proceedings of the Joint Meeting of the 13th European Frequency and Time Forum and IEEE International Frequency Control Symposium 12-16 April 1999, volume 2, p686-91, (IEEE catalog number 99CH36313).

[3] M.G. Boshier, G.P. Barwood, G. Huang and H.A. Klein, to be published in Appl. Phys. B (2000).