On the prospects of building optical atomic clocks using Er I or Er III

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Atomic clocks are widely used in many areas of science and industry due to their extremely high accuracy. Frequency standards based on optical transitions in neutral atoms trapped in optical lattice aim at fractional accuracy of 10^{-18}. One order of magnitude improvement would allow testing the so-called α-dipole hypothesis which claims that the fine structure constant α is different in different places of Universe, changing smoothly along a certain direction in space[1]. Terrestrial measurements with such an atomic clock could detect[2] gradient of fine structure constant due to motion of our galaxy towards the area with larger α. One of the main problems on the way to improving the accuracy of existing clocks is black body radiation (BBR) shift.

It was suggested[3] to use highly charged ions with the $4f^{12}$ configuration of valence electrons (isoelectronic sequence from Os^{18+} to U^{34+}. A very narrow electric quadrupole transition was shown to have a very small difference of scalar polarizabilities which lead to suppression of BBR shift.

We showed[4] that neutral and double ionized Erbium have similar to highly charged ions properties that make them candidates for new generation of atomic clocks. Both systems are not sensitive to BBR shift due to extremely small difference of scalar polarizabilities. Dominating systematic shift comes from coupling of the atomic quadrupole moments to the gradients of electric field. However, this shift can be strongly suppressed by averaging over transitions with different projections of the total angular momentum. Other systematic shifts are either small or can be suppressed. The fractional accuracy of at least 10^{-18} is achievable for both types of clocks.

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