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Enhancement of the effects of space-time variation of the fundamental constants in collisions of cold atoms near Feshbach resonances

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Synopsis New results based on the quasar absorption data indicate variation of the fine structure constant alpha in space. These results are tested in different astrophysical measurements and laboratory experiments with atomic and nuclear clocks. Systems with enhanced effects of the variation may be especially important. Huge enhncement of the effects of space-time variation of the fundamental constants appears in collisions of cold atoms near Feshbach resonances.

Recent results for the variation of the fine structure constant alpha based on the quasar absorption spectra data indicate the variation of alpha in space [1]. The spatial variation can explain fine tuning of the fundamental constants which allows humans (and any life) to appear. We appeared in the area of the Universe where the values of the fundamental constants are consistent with our existence. There is an agreement between the results obtained using different telescopes and different redshifts. Also, now there are no contradictions between the results obtained by different groups. Other results and methods to search for the variation in astrophysics are also discussed. These astrophysical results may be used to predict the variation effects for atomic clocks which are very small and require improvement of the sensitivity by 1-2 orders of magnitude. This improvement may be achieved using 229Th nuclear clocks where the effect of the variation is hugely enhanced. There are also enhanced effects in multiply charged ions [2, 3], and certain atomic and molecular transitions.

There is a very strongly enhanced sensitivity to the fundamental constants in ultracold atomic and molecular systems near Feshbach resonances [4, 5]. Scattering length, which can be measured in Bose-Einstein condensate and Feshbach molecule experiments, is extremely sensitive to the variation of fundamental constants, in particular, the electron-to-proton mass ratio m_e/M_p. Based on single- and two-channel scattering models, we show how the variation of the mass ratio propagates to the scattering length. Our results suggest that effect of the variation of m_e/M_p may be enhanced up to 10^{12} times near a narrow magnetic or an optical Feshbach resonance. Derived formulas may also be used to estimate the isotopic shift of the scattering length.

References

[1] K. Webb, J. A. King, M. T. Murphy, V. V. Flambaum, R. F. Carswell, M. B. Bainbridge 2011 *Phys. Rev. Lett.* **107** 191101.

[2] J. C. Berengut, V. A. Dzuba and V. V. Flambaum, 2010 *Phys. Rev. Lett.* **105** 120801.

[3] J. C. Berengut, V. A. Dzuba, V. V. Flambaum, A.Ong 2011 *Phys. Rev. Lett.* **106** 210802.

[4] C. Chin, V.V. Flambaum 2006 *Phys. Rev. Lett.* **96** 96, 230801.

[5] K. Beloy, A. Borschevsky, V. V. Flambaum, and P. Schwerdtfeger 2011 *Phys. Rev. A* **84** 042117.

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