Elucidating energy shifts in optical tweezers

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A small piece of paper sticks to an electrically charged plastic ruler. The principle of this simple classroom physics experiment is applied at the microscopic scale by so-called optical tweezers to get the likes of polystyrene micro-beads and even living cells to "stick" to a laser beam, or to trap atoms at ultra-low temperatures. Physicist Fam Le Kien and his colleagues from the Institute of Atomic and Subatomic Physics of the Vienna University of Technology, Austria, provide a comprehensive manual with general theoretical tools, definitions, and spectroscopic data sets for calculating the energy levels of atoms, which are modified by light emanating from optical tweezers, in a study about to be published in *European Physical Journal D*.

One issue that occurs when trapping atoms with optical tweezers is that the laser beam modifies atoms' energy levels. As a result, it changes the frequency at which the atoms emit or absorb light and microwave radiation. Depending on the experiment, this effect can have important consequences and its magnitude might need to be calculated. Interestingly, the change in the energy levels can be seen as partly due to a fictitious magnetic field, induced by the light field effect on the atoms. This is akin to introducing fictitious forces when describing a body's motion in a rotating reference frame.

The authors show that these fictitious magnetic fields add up to the same effect as real magnetic fields. This will help physicists to intuitively foresee the effects that occur in their experiments when external magnetic fields either cannot be avoided or are intentionally applied. Ultimately, this all-in-one guide could be used in fundamental research

as well as for applications such as quantum simulators and quantum computers.

More information: Fam Le Kien et al. (2013), Dynamical polarizability of atoms in arbitrary light fields: General theory and application to cesium, *European Physical Journal D*. DOI: 10.1140/epjd/e2013-30729-x