Journal of Physics B: Atomic, Molecular and Optical Physics

Sensitivity to weak perturbations

Coherent production of metastable hydrogen-like ions at the x-ray energy regime

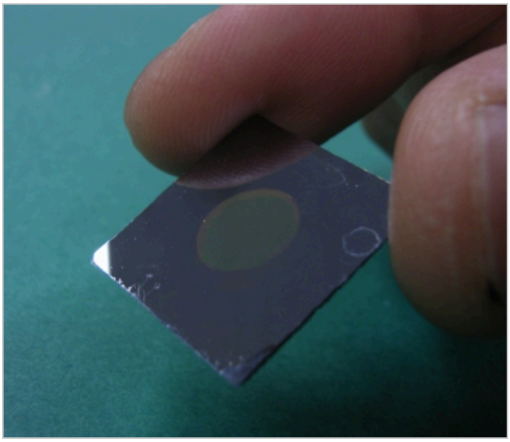


Figure 2. Photo of the 1 μm-thick silicon crystal.

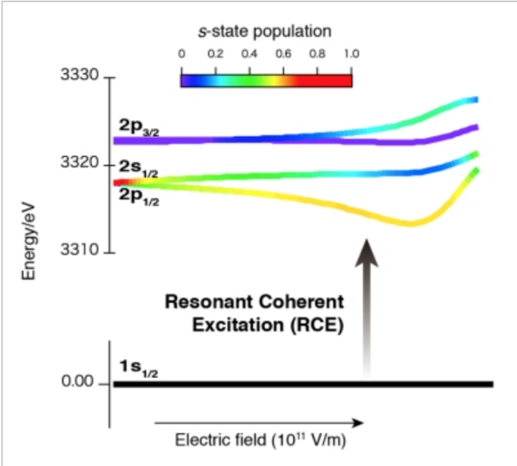


Figure 1. Resonant coherent excitation to the n = 2 state in (...)

Metastable states are optically forbidden to decay into lower-energy states through the electric dipole interaction. This means that the ions in metastable states are highly sensitive to other internal or external weak perturbations prompting their decay. Researchers from RIKEN have demonstrated a novel scheme to produce metastable hydrogen-like ions through a coherent excitation from the ground state (published in 2015 *J. Phys. B: At. Mol. Opt. Phys.* 48 144026). The scheme uses Stark mixing of optically allowed wave functions into the metastable state, making the electric dipole excitation from the ground state possible.

The 1s population in hydrogen-like Ar^{17+} was coherently transferred to the metastable 2s state via the Stark-mixed states in the presence of an intense static field as shown in figure 1. The experimental result was quantitatively supported by a density matrix calculation performed by researchers from the theory group at the Russian Academy of Sciences. The new scheme is a powerful tool to probe the relativistic effect on the decay of the 2s state with an unprecedented sensitivity.

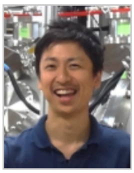
Getting a coherent electromagnetic field at 3 keV under a strong static field

A single piece of silicon crystal provides both a static field with a gradient of 1011 V m^{-1}, and an electromagnetic field with an intensity of 1015 W cm^{-1} at the energy of 3 keV. Instead of being exposed to laser fields, the Ar^{17+} ions were accelerated to a relativistic velocity and shot into a thin Si crystal (1 μm-thick) in such a way that the ions travel parallel to one of the atomic planes in the crystal. A continuum Coulomb field along the atomic plane induced the Stark shift of the n = 2 state of the ions, and simultaneously, coherent interaction with periodic atomic strings on the plane triggered the excitation at a resonant frequency.

More details of the authors work is published in *Journal of Physics B: Atomic, Molecular, and Optical Physics.*

About the author

Dr Yuji Nakano is a Research Scientist at the Atomic, Molecular & Optical Physics Laboratory, RIKEN, Japan headed by **Professor Toshiyuki Azuma**. The group studies population control of highly charged heavy ions in the x-ray energy regime using resonant coherent excitation. **Dr Alexey Sokolik** is a researcher at the Institute for Spectroscopy, Russian Academy of Sciences, Russia and performed the theoretical calculation using a density matrix approach.



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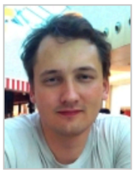

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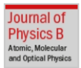

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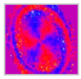
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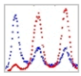
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