SYKL 1: Resonant laser-nucleus interactions

Zeit: Dienstag 8:30–10:30 Raum: 1A

Hauptvortrag SYKL 1.1 Di 8:30 1A

Status of research into isomer depletion reactions — •James J. Carroll — Department of Physics and Astronomy, Youngstown State University, One University Plaza, Youngstown, Ohio 44555 USA

Nuclear isomers are attractive targets for study since their very existence reflects specific structural barriers to transitions between them and other nuclear levels. An inhibition of isomer decay corresponds to an intriguing ability to store energy at high densities, particularly for long-lived isomers with half-lives longer than a day. Apart from a basic physical interest in isomerism, the potential for practical applications of this form of energy storage has provided an additional impetus for research. To this point, experimental studies have primarily focused on resonant interactions between nuclei and external stimulae, like photons, by which to induce a depletion of isomeric populations through intermediate states. Currently induced depletion has been demonstrated for three isomers, ^{180m}Ta, ^{177m}Lu and ^{68m}Cu, and additional tests are underway or anticipated for other isomers. The cross sections for resonant depletion reactions appear to be relatively small. However, non-resonant processes like NEET and NEEC have been suggested as means of enhancing the efficiency of isomer depletion through a coupling between atomic and nuclear transitions. This talk will survey the status of research into resonant depletion of isomers and look ahead to new directions related to non-resonant processes.

Hauptvortrag SYKL 1.2 Di 9:00 1A

Optical access to the lowest nuclear transition in ^{229}Th* — •Peter G. Thirolf, Michael Bussmann, Dietrich Habs, Hans-Jörg Maier, Jürgen Neumayr, Jörg Schreiber, Michael Sewtz, and Jerzy Szerypo — Ludwig-Maximilians-Universität München and Maier-Leibnitz Laboratory, Garching, Germany

The isomeric first excited state of ^{229}Th is known to be the lowest excitation in the whole chart of nuclei. For a long time its nuclear level energy was reported as 3.5±0.5eV. In a recent experiment this transition energy was remeasured, resulting in an important change of the energy to E_γ=(7.6±0.5) eV, corresponding to a transition wavelength of λ=(163 ± 11)nm [1]. The estimated lifetime of the level is τ= 3-5 hours, which corresponds to a relative line width of about 10^{-20}, 5 to 6 orders of magnitude smaller than typical relative atomic line widths measured in experiments with single laser-cooled ions. The ^{229m}Th transition appears to be the most sensitive probe for studying the time dependence of the fine structure constant α and quark masses. We are presently working on a stepwise approach to confirm the excitation energy and the long lifetime of ^{229m}Th, aiming at a measurement of the transition energy with increasing accuracy. Since possible lasers for λ=(163 ± 11)nm depend very much on the exact transition wave length, the question of directly exciting the nucleus can only be addressed after the transition energy has been determined more accurately in nuclear excitation.

[1]: B.R. Beck et al., PRL **98** (2007) 142501.

* Supported by the DFG Cluster of Excellence MAP (Munich-Centre for Advanced Photonics)

Hauptvortrag SYKL 1.3 Di 9:30 1A

Direct interaction of nuclei with superintense laser fields — •Thomas Bürvenich — Frankfurt Institute for Advanced Studies, Frankfurt, Germany

The direct interaction of nuclei with superintense laser fields is studied. While direct laser-nucleus interactions have often been dismissed, we demonstrate that present and upcoming high-frequency laser facilities do allow for resonant laser-nucleus interaction. These direct interactions may be utilized for the model-independent optical measurement of nuclear properties or the preparation and control of nuclear states [1]. We further study non-resonant direct laser-nucleus interactions such as the dynamic nuclear Stark shift [2]. While electric dipole-allowed transitions in nuclei correspond most closely to atomic quantum optics, it is shown that in nuclei non-electric-dipole transitions are promising candidates [3]. Perspectives for the field of nuclear quantum optics are given.

[1] T. J. Bürvenich, J. Evers, and C. H. Keitel, Phys. Rev. Lett. 96, 142501 (2006)

[2] T. J. Bürvenich, J. Evers, C. H. Keitel, Phys. Rev. C 74, 044601 (2006)

[3] A. Pálffy, J. Evers, and C. H. Keitel, arXiv:0711.0015

Hauptvortrag SYKL 1.4 Di 10:00 1A

Aspects of Electromagnetically induced transparency using nuclear radiation — •Jos Odeurs — Katholieke Universiteit Leuven, Instituut voor Kern- en Stralingsfysica, Celestijnenlaan 200D, B-3001 Leuven, Belgium

Coherence and interference using gamma radiation has led to the relatively new field of nuclear quantum optics. It deals with the resonant interaction of single gamma photons with an ensemble of nuclei incorporated in a solid-state lattice. Gamma ray sources having an extremely narrow energy spectrum (of the order of 10-9 eV) can be produced because of recoilless emission, i.e., the Mössbauer effect, which eliminates the phonon line broadening. Electromagnetically induced transparency (EIT) is the phenomenon, known in atomic quantum optics, where a resonant medium can become transparent for radiation by applying another coherent radiation field. An important deficit in absorption under well-defined conditions has been observed for gamma radiation emitted by the 14.4 keV excited state of 57Fe passing through a single crystal of FeCO3. The experiment will be described and the theory, based on a variation of EIT in the nuclear realm, called level-mixing induced transparency, will be outlined.

Slow group velocity for gamma radiation will be discussed. For the experiments on FeCO3, the group velocity of the single gamma photons can be estimated at 1 km/s.