A 30: Precision Spectroscopy of Atoms and Ions V

Zeit: Donnerstag 16:30–17:45 Raum: VMP 6 HS-B

Fachvortrag A 30.1 Do 16:30 VMP 6 HS-B

Accurate absolute frequency and isotope shift measurements of the 3s-3p doublet in $^{24-26}Mg^+$ — •Valentin Batteiger[1], Sebastian Knünz[1], Maximilian Herrmann[1], Guido Saathoff[1], Thomas Udem[1], and Theodor W. Hänsch[1,2] — [1]Max–Planck–Institut für Quantenoptik, 85748 Garching, Germany — [2]Ludwig–Maximilians–Universität München, 80539 München, Germany

We present an isotopically resolved absolute frequency measurement of both fine structure components of the 3s-3p transition near 280nm in Mg^+. When red-shifted into the transparency range of our atmosphere, the doublet is frequently observed in astronomical spectra. Thus the transitions are good probes of physics at early epochs. Together with other strong UV transitions both lines where requested for improved measurement on the quest for a possible space-time variation of the fine structure constant 7-11 billion years ago. We performed a series of absolute frequency measurements on single trapped magnesium ions. Owing to a new spectroscopy method we could improve the values of the transition frequencies, fine structure splitting and isotope shifts by more than two orders of magnitude.

A 30.2 Do 17:00 VMP 6 HS-B

Direct Frequency Comb Spectroscopy of Metal Ions using Quantum Logic — •Boerge Hemmerling[1], Daniel Nigg[1], Lukas An der Lan[2], Birgit Brandstätter[2], and Piet O. Schmidt[1] — [1]QUEST Institute for Quantum Metrology, Physikalisch-Technische Bundesanstalt, Leibniz Universität Hannover, Braunschweig, Germany — [2]Institut für Experimentalphysik, Universität Innsbruck, Austria

Improving the interpretation of quasar absorption spectra for the search of a possible temporal variation of the fine-structure constant on cosmological time scales requires more precise frequency measurements of certain transitions in metal ions such as Ca^+, Ti^+ and Fe^+ [1].

We are developing a versatile setup for precision spectroscopy of these ions with a complex level structure. The ions are sympathetically cooled by $^{25}Mg^+$ in a linear Paul trap. A femto-second optical frequency comb will be used as a tunable spectroscopy probe, ideally covering the whole spectrum of interest. Quantum logic techniques will be employed for efficient state preparation, ground state cooling and detection of the spectroscopy signal. We will present the latest results of our experiments and a detailed theoretical analysis of the interrogation scheme for Ca^+. We expect that direct frequency comb spectroscopy produces a maximum fluorescence rate of ($\sim$ 100 photons/s), which will be detected by measuring the increase of the vibrational quantum number of the ion crystal due to photon scattering.

[1] J. C. Berengut, V. A. Dzuba, V. V. Flambaum, M. V. Marchenko and J. K. Webb, arXiv:physics/0408017 (2006)

A 30.3 Do 17:15 VMP 6 HS-B

Detektion der Bewegungsfrequenzen eines Protons in der Mainzer g-Faktor Apparatur — •Holger Kracke[1], Klaus Blaum[2], Susanne Kreim[1], Andreas Mooser[1], Christian Mrozik[1], Wolfgang Quint[3], C. C. Rodegheri[1], Stefan Stahl[5], Stefan Ulmer[1,2,3,4] und Jochen Walz[1] — [1]Institut fürPhysik, Universität Mainz, 55128 Mainz, — [2]MPI für Kernphysik, 69117 Heidelberg, — [3]GSI,64291 Darmstadt, — [4]Ruprecht-Karls-Universität,69047 Heidelberg, — [5]Stahl-Electronics, 67582 Mettenheim

Der g-Faktor des Protons soll aus dem Verhältnis der freien Zyklotronfrequenz ν_c und der Larmorfrequenz ν_L bestimmt werden. Um eine hohe Messgenauigkeit zu erzielen, wird die Messung an einem einzelnen Proton durchgeführt. Dies setzt die zerstörungsfreie Detektion der Eigenfrequenzen des Teilchens in der Penning-Falle voraus. Dabei werden die vom Teilchen in den Fallenelektroden induzierten Spiegelströme als Spannungsabfall über einem externen Schwingkreis nachgewiesen. Die kryogene Umgebung erlaubt die Verwendung supraleitender Materialien und rauscharmer Elektronik. Die somit erreichte hohe Güte des axialen Schwingkreises von $Q \approx 5000$ ermöglicht eine Detektion der axialen Mode eines einzelnen Protons im thermischen Gleichgewicht über den Dip im Rauschspektrum des Schwingkreises. Die Magnetronfrequenz ν_- wird anhand eines "Avoided Crossings*"gemessen. Ausserdem wird die reduzierte Zyklotronfrequenz ν_+ über eine Kühlkurve detektiert und somit kann die freie Zyklotronfrequenz über $\nu_c^2 = \nu_-^2 + \nu_z^2 + \nu_+^2$ bestimmt werden.

A 30.4 Do 17:30 VMP 6 HS-B

Precision measurement of decay branching ratios in a single trapped Ca^+ ion — •Rene Gerritsma[1], Gerhard Kirchmair[1,2], Florian Zähringer[1,2], Jan Benhelm[1,2], Rainer Blatt[1,2], and Christian Roos[1,2] — [1]Institut für Quantenoptik und Quanteninformation, Österreichische Akademie der Wissenschaften, Otto-Hittmair-Platz 1, A-6020 Innsbruck, Austria — [2]Institut für Experimentalphysik, Universität Innsbruck, Technikerstr. 25, A-6020 Innsbruck, Austria

We report on precision measurements of the $4P_{3/2}$ decay branching ratios in Ca^+ [R. Gerritsma et al., Eur. Phys. J. D 50, 13 (2008)]. Absorption and emission lines in Ca^+ have been used in many astrophysical observations, such as of galaxies, interstellar clouds and dust disks surrounding stars. Here, an accurate knowledge of transition frequencies and oscillator strengths is desired. On the theoretical side considerable effort is devoted to precise structure calculations of singly charged alkali earth ions such as Ca^+. For comparison to theory precise measurements of branching ratios and lifetimes are needed. Measurements of these quantities in literature are often based on experiments in ion beams or trapped clouds of ions. In our approach, the use of a single trapped ion eliminates errors due to depolarizing collisions while allowing high fidelity state preparation and detection. Furthermore, we improve the precision by a new technique based on repetitive pumping to the $4P_{3/2}$ state. In this way we determine the branching fractions with sub-precent precision and a forty-fold improvement with respect to the previously best known values.