Laser spectroscopy measurement of isotope shifts and nuclear moments of short-lived neon isotopes

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Within the scope of a laser spectroscopy study of nuclear structure in the *sd* shell we are measuring nuclear moments and isotope shifts of neon isotopes. An ultra-sensitive variant of collinear laser spectroscopy [1, 2] is applied to a neutralized fast beam from ISOLDE (CERN). The non-optical detection is based on optical pumping, state selective collisional ionization and β-activity counting. This method gives access in particular to the short-lived isotopes in the extended chain of $^{17-26,28}$Ne.

The small effect of nuclear charge radii on optical isotope shifts of light elements requires very accurate measurements [4]. The errors are dominated by uncertainties of the Doppler shifts as long as these are determined from measurements of the acceleration voltage. These uncertainties are eliminated by performing a direct Doppler shift measurement of the beam energy using the simultaneous excitation of two optical lines with the same laser in parallel/antiparallel beam configuration. This technique yields the energy of the neutral 60 keV neon beam to less than 1 eV.

With the inclusion of this beam energy calibration it was possible to determine the isotope shift with respect to the reference ^{20}Ne with a precision close to 1 MHz. The field shift and differences in ms nuclear charge radii were extracted using absolute nuclear charge radii from X-ray spectroscopy on muonic atoms [5] and an electronic factor of $-40(4)$ GHz/fm^2 from semi-empirical calculations. It turns out that nuclear structure effects in the radii are fairly well resolved.

In addition to the charge radii the nuclear moments of the odd-A isotopes were determined from their atomic hyperfine structure. The hyperfine structure parameters, the magnetic dipole moments of the isotopes ^{17}Ne and ^{25}Ne, and the electric quadrupole moment of ^{23}Ne were determined for the first time. Furthermore the spin of ^{25}Ne was determined to be 1/2.

In addition to the structure of lower *sd*-shell nuclei far from stability the experiment yields key information on ^{17}Ne at the proton drip line. This isotope is one of the most promising candidates for a proton-halo structure. A measurement of the charge radius is much more sensitive to proton halo effects and also more accurate than the existing data on matter radii. Another test for halo properties is offered by the nuclear magnetic moment. From a recent experiment [3] also the magnetic moment of the mirror nucleus ^{17}N is known. The preliminary analysis shows that both magnetic moments deviate in similar ways outwards from the Schmidt values. The isoscalar moment shows mirror symmetry in the appreciable *sd*-shell contribution from the last proton pair of ^{17}Ne (presumably forming the halo) and the neutron pair of ^{17}N.

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