HGS-HIRe for FAIR
Helmholtz Graduate School for Hadron and Ion Research

Lecture Week „*Nuclear Structure: Shell Structure of Complex Nuclei*"

Proposals for experiment oriented topics

1. *Title*: **Weekly bound Nuclei: ^{11}Li**

Task: At the limit of stability, towards the proton and neutron driplines excess nucleons lead to new features of nuclear matter. For light nuclei the wave functions of those valence nucleons extend very far out to extremely large radii, leading to a large region of relatively low nuclear density, so called nucleonic halos. For heavier neutron rich systems which will be accessible with new radioactive beam facilities like FAIR even more spectacular features like neutron skins are expected with consequences even for nuclear astrophysics and stellar nucleosynthesis. This contribution will present the basic features of light halo nuclei like ^{11}Li and show the perspectives of the study of dripline nuclei in view of upcoming radioactive beam facilities.

Literature:

[1] I. Tanihata et al., Phys. Rev. Lett. 55, 2676 (1985)
[2] P. Egelhof et al., Eur. Phys. J. A 15, 27 (2002)
[3] H. Simon et al., Phys. Rev. Lett. 83, 496 (1999)
[4] http://www.nuclearhalo.info/index.htm

2. *Title*: **N = Z (^{100}Sn)**

Task: ^{100}Sn is the heaviest bound N=Z nucleus. It is at the same time a doubly magic nucleus with Z=N=50. It therefore is, sometimes called "the holy gral", of special interest for basic nucleon-nucleon interaction studies like e.g. the investigation of the monopole migration concept. It has been first discovered at the GSI Fragment Separator (FRS) and at the fragmentation facility at GANIL, Caen, France. In a recent experiment at the FRS the first γ-decay spectra in coincidence with ^{100}Sn β-decays have been obtained providing information on basic decay properties. This presentation will introduce the fragmentation facility FRS at GSI (projectile fragmentation and projectile fission) and discuss the ^{100}Sn production as one application of the device, laying out the main nuclear structure features of this special nucleus.

Literature:

[1] H. Geissel et al., Nucl. Instrum. Meth. B70, 286 (1992)
[2] K. Sümmerer et al., Nucl. Phys. A 616, 341 (1997)
[3] T. Otsuka et al., PRL 95, 232502 (2005)
[4]http://www.gsi.de/informationen/wti/library/scientificreport2009/PAPERS/NUSTAR-EXPERIMENTS-19.pdf

3. *Title:* **Collective Properties of exotic Nuclei: Pygmy resonance – ^{132}Sn**

Task: Collective excitations of nuclei manifest themselves in various oscillation modes of the nucleonic species, neutrons and protons, the giant resonances. Adding more and more neutrons to a system leads to asymmetric nuclear matter. The neutron excess is the origin of new collective resonant features like the so called "pygmy" resonance. In this contribution the authors will give an overview of the various collective resonant oscillations in nuclei including the "pygmy" resonance.

Literature:

[1] P. Adrich et al. Phys. Rev. Lett. 95, 132501 (2005)
[2] J. Endres Phys. Rev. Lett. 105, 212503 (2010)
[3] http://www.phy.hr/~npaar/pygmy/index.html

4. *Title:* **Structure of the Heaviest: K-Isomerism for Very Heavy Nuclei (^{25x}No)**

Task: The superheavy elements (SHE) are a nuclear structure phenomenon. They owe their existence to the quantum mechanical origin of shell correction energies without which they would not be bound. The investigation of the nuclear level structure and the trends of single particle levels towards the searched for energy gap is a basic ingredient for SHE research. Among the most interesting features is the observation of K-isomeric states in deformed very heavy and superheavy nuclei. In this presentation, the basic features of the K quantum number and K-isomerism have to be explained and an overview of what is known on K-isomerism in the region Z>100 has to be given.

Literature:

[1] R.-D. Herzberg and P.T. Greenlees, Prog. Part. Nuc. Phys. 61, 674 (2008)
[2] P.M. Walker and G.G. Dracoulis, Nature 399, 35 (1999)
[3] K.E.G. Löbner, Phys. Lett. B 26, 369 (1968).

5. *Title:* **Structure of the Heaviest: Precision Mass measurements and Binding Energies**

Task: The validity of models predicting the stability of superheavy nuclear systems depends strongly on the knowledge of basic properties of nuclear matter. The nuclear mass reflects directly the binding energy of a heavy nucleus. Precise mass measurements in penning traps have been developed to a point that now even nuclei with production rates down to 1 per hour and less have become accessible. This contribution will present the principle of nuclear mass measurements in penning traps and their application to nuclei in the region of Z>100 and A>250.

Literature:

[1] K. Blaum, High-accuracy mass spectrometry with stored ions, Phys. Rep. 425, 1 (2006)
[2] G. Bollen et al., J. Appl. Phys. 68 (1990) 4355
[3] M. Block et al., Nature 463, 785 (2010).