Spectroscopic factors for single nucleon transfer on magic nuclei with slow beams at RISING

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Beyond the magic number N,Z=20 the increasing spin-orbit splitting for *high-l* orbits creates new shell gaps above the high-spin $j = l + 1/2$ orbital such as $f_{7/2}$, $g_{9/2}$ and $h_{11/2}$ and its low-spin partners from the same major shell, which gives rise to the familiar Woods- Saxon type jj coupling magic numbers 28, 50, 82, etc. Due to the *ls*-open core, which allows stretched $\Delta l = 1, 2$ $j, l + 1/2 \rightarrow j, l - 1/2$ resp. $j, l + 1/2 \rightarrow j - 2, l - 3/2$ transitions, the doubly magic core is soft with respect to $np - nh$ excitations. It was shown in large scale shell model calculations [1] and in the Monte-Carlo shell model approach [2] in the full (f,p) shell, that the closed shell configuration $1f^{16}$ covers only 50-60% of the ^{56}Ni ground state, the rest being up to *8p8h* excitations.

At N $\gg$ Z due to the dilute nuclear surface, which reduces the spin- orbit splitting, the disappearance of the familiar Woods-Saxon shell closures and their reappearance as harmonic oscillator magic numbers is expected. It is an intensively discussed questions, whether this could be already realised at N=40 for ^{68}Ni, as the experimental evidence is contradictory [3]. For ^{132}Sn almost all candidates for single particle (hole) states are known, but their spectroscopic strength is unknown. Again a change in shell structure is expected for the N>82 isotopes and the Z<50 isotones of ^{132}Sn.

While the hole spectroscpopic strength in general can be studied best in nucleon removal reactions at relativistic energies, as has been demonstrated in light nuclei, the particle spectroscopic factors can be best measured in stripping reactions at beam energies below 20 MeV/A. There are three regions of specific interest that are accessible to Rising at slowed-down beams:

- In the N=Z nucleus ^{56}Ni the (d,p) reaction was recently studied in inverse kinematics in a pioneering experiment with, however, limited accuracy for the spectroscopic factor [4]. The RIB intensities expected at RISING exceed the intensities in this experiment by an order of magnitude, i.e. 5 $\times 10^5$ /s in ^{58}Ni fragmentation. The main physics goal in this case is the amount of core excitaions and its development when moving away from the N=Z line.

- The contradictory conclusions about the doubly-magic character of ^{68}Ni calls for a detailed study of spectroscopic strength to disentangle the possible influence of deformation and/or pairing. The expected rate in fragmentation of ^{70}Zn is 10^5 /s .

- Studies at ^{132}Sn presently are limited by the low secondary beam intensities of 230 /s in the fission of ^{238}U, which may increase in the future when the ^{238}U beam intensities reach the design values 6 $\times 10^9$ /s .studies would be possible for lighter Sn isotopes, which are accessible by fragmentation.

The kinematics of inverse stripping and pickup reactions has been intensively studied in the past [5-7]. As a consequence a setup consisting of RISING and a charged particle detector array for light ejectiles covering a laboratory angle from 30^0 - 150^0

besides the beam tracking detectors. First the (d,p) reaction in inverse kinematics will be studied, the possibility of exploiting the (d,n) reaction with an appropriate neutron detector at backward laboratory angles is a future option. The rôle of RISING in this proposal is the need for energy resolution which can only be obtained by γ-spectroscopy, and including Doppler broadening is expected to be better than 25 keV. This also allows use of thick targets up to 3 mg/cm^2. Asumming a γ-efficiency of 7% we expect for ^{56}Ni a statistics in γ's, that exceeds the previous experiment [4] by an order of magnitude.

A further option of these experiments is a combination with the differential plunger setup proposed by A. Dewald et al., which due to the large recoil velocity would allow for lifetime measurements in the pico-second regime.

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