HK 18: Nukleare Astrophysik I

Time: Tuesday 14:00–16:00 Location: HS3

Group Report HK 18.1 Tue 14:00 HS3

Microscopic calculation of the ^{3}He(α,γ)^{7}Be reaction rate using realistic interactions — •Thomas Neff, Hans Feldmeier, and Karlheinz Langanke — GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt

We calculate the radiative capture cross sections for the ^{3}He(α,γ)^{7}Be and the ^{3}H(α,γ)^{7}Li reactions in the fully microscopic Fermionic Molecular Dynamics approach using a realistic effective interaction obtained in the Unitary Correlation Operator Method. At large distances bound and scattering states are described by antisymmetrized products of ^{4}He and ^{3}He/^{3}H ground states. At short distances the many-body Hilbert space is extended with additional many-body wave functions obtained by variation after parity and angular momentum projection. These additional configurations are needed to represent polarized clusters and shell-model like configurations. Properties of the bound states like binding energies, charge radii and quadrupole moments are described well, as are the scattering phase shifts. The calculated S-factor for the ^{3}He(α,γ)^{7}Be reaction agrees very well with recent experimental data both in absolute normalization and energy dependence. In case of the ^{3}H(α,γ)^{7}Li reaction the calculated S-factor is larger than the experimental data by about 15%.

HK 18.2 Tue 14:30 HS3

Study of the ^{2}H(α,γ)^{6}Li reaction at LUNA — •Michael Anders and Daniel Bemmerer for the LUNA-Collaboration — Forschungszentrum Dresden-Rossendorf (FZD), Dresden, Germany

Observations of very metal poor stars have yielded evidence for the less abundant lithium isotope ^{6}Li in several cases. These findings prompt the question whether there is a non-negligible primordial contribution to the observed ^{6}Li abundances. Network calculations show that the ^{2}H(α,γ)^{6}Li reaction dominates ^{6}Li production in the Big Bang. A recent Coulomb dissociation work on this reaction produced only an upper limit for the astrophysical S-factor. At the 400 kV underground accelerator LUNA in Gran Sasso/Italy, an experiment is underway to gain direct cross section data, but the background is formidable. Preliminary data of the first phase of the LUNA experiment will be shown, and an outlook will be given. – Supported by INFN and by DFG (BE 4100/2-1).

HK 18.3 Tue 14:45 HS3

Simulation of the ^{7}Li(p, n)^{7}Be reaction — •Stefan Schmidt, Oliver Meusel, and Rene Reifarth — Goethe-Universität Frankfurt, Max-von-Laue-Straße 1

The neutron spectrum of the ^{7}Li(p, n) reaction has long been used as an approximation to the thermal neutron distribution in Red Giant stars. The angle-integrated spectrum approximating the Maxwellian distribution at 25 keV very well can be used to investigate neutron capture cross sections. It is well understood and simulation tools agree with the measurements. However, future projects continuing the work of Karlsruhe Institute of Technology (KIT, formerly FZK) require more in-depth knowledge of the resulting neutrons. To provide this information, a simulation tool has been developed that works with six-dimensional proton input to generate six-dimensional neutron output. Its results agree very well with angle-dependent measurements conducted at KIT and Physikalisch-Technische Bundesanstalt, thus it allows analyzing the dependency of the neutron spectrum on the proton input and helps to study effects like phase space occupation.

HK 18.4 Tue 15:00 HS3

Coulomb Dissociation of ^{17}Ne and its role for nuclear astrophysics — •Justyna Marganiec[1], Thomas Aumann[2,3], Michael Heil[2], Ralf Plag[2,4], and Felix Wamers[2,3] for the R3B-Collaboration — [1]ExtreMe Matter Institute EMMI, GSI Darmstadt, Germany — [2]Kernreaktion und Nuklear Astrophysik, GSI Darmstadt, Germany — [3]Institut für Kernphysik, TU Darmstadt, Germany — [4]Goethe-Universität, Frankfurt am Main, Germany

The study of the Coulomb break up of ^{17}Ne gives us an access to information about the time-reversed reaction ^{15}O$(2p,\gamma)^{17}$Ne, which could serve as a bypass of ^{15}O waiting point during the *rp* process, and move the initial CNO material towards heavier nuclei.

The three-body radiative capture can proceed sequentially (J. Görres, *et al.*, *Phys. Rev. C* **51**, 392, 1995) or directly from the three-body continuum (L.V. Grigorenko, M.V. Zhukov, *Phys. Rev. C* **72**, 015803, 2005). It has been suggested that the reaction rate can be enhanced by a few orders of magnitude by taking into account the three-body continuum. In order to verify these calculations, the ^{15}O$(2p,\gamma)^{17}$Ne cross section has been investigated.

The experiment has been performed at the LAND/R^{3}B setup at GSI, using the fragment separator FRS to select a ^{17}Ne secondary beam.

This project is supported by BMBF, EU (EURONS), EMMI, and FIAS.

HK 18.5 Tue 15:15 HS3

A possible underground accelerator in the Dresden Felsenkeller — •Daniel Bemmerer[1], Thomas Cowan[1,2], Tamás Szücs[1,3], and Kai Zuber[2] — [1]Forschungszentrum Dresden-Rossendorf (FZD), Dresden — [2]TU Dresden — [3]ATOMKI, Debrecen, Ungarn

Due to the suppression by the Coulomb barrier, the cross section of astrophysically relevant nuclear reactions is very low at the stellar energy. Therefore it can only be directly measured in a low-background environment. For more than a decade, the LUNA collaboration has pursued this approach with a 0.4 MV accelerator in the Gran Sasso underground laboratory in Italy. It was highly successful in studying nuclear reactions in the Sun and in the Big Bang. However, the energy range of LUNA is not sufficient to address the nuclear reactions of stellar helium burning and the neutron source reactions for the astrophysical s-process. Therefore, in the NuPECC 2010 draft long range plan it is recommended to install one or more higher energy accelerators underground. A dedicated comparison of the background at LUNA (1400 m rock cover) and the Dresden Felsenkeller (45 m) has shown that with an anti-muon veto the background counting rates in a γ-detector differ only by a factor of three. The feasibility of installing a 2-3 MV accelerator for intensive α-beams in Felsenkeller is discussed.

HK 18.6 Tue 15:30 HS3

Coulomb breakup of the r-pocess waiting point nucleus ^{18}C — •Marcel Heine for the R3B-Collaboration — TU Darmstadt

Recent research has shown that the (n,γ) transition rates on light nuclei can have an influence on the neutron balance during the r-process. Especially neutron rich carbon isotopes play an important role in r-process nucleosynthesis network calculations which included light nuclei. In particular ^{18}C is of interest, since it can be interpreted as a waiting point. The rate of the production reaction ^{17}C(n,γ)^{18}C could so far only be estimated theoretically and has an uncertainty of a factor of 10 [1]. At the R^{3}B/LAND setup at GSI we have studied the (n,γ) time reversed reaction, i.e. ^{18}C(γ,n)^{17}C via the Coulomb breakup of ^{18}C beam. The kinematically complete measurement allows extracting the differential cross section with respect to the excitation energy by using the invariant-mass method. First results and the strategy for further analysis will be presented.

[1] T. Sasaqui et al., APJ 634 (2005) 1173

HK 18.7 Tue 15:45 HS3

Coulomb dissociation reactions on proton-rich Argon isotopes — •Christoph Langer[1,2] and Olga Lepyoshkina[3] for the R3B-Collaboration — [1]IKP Institut für Kernphysik, Universität Frankfurt am Main, Germany — [2]GSI Darmstadt, Germany — [3]Physik Department TU-Muenchen, Garching, Germany

The rapid proton capture (rp-)process is an important part of explosive hydrogen burning scenarios. Far from stability proton capture rates are dominantly governed by only a few resonances and as a consequence statistical models are not applicable any more. The rp-process reaction flow in X-ray bursts has an important bottleneck in the ^{30}S-^{34}Ar region. The exotic nuclei of this region are of interest with respect to nuclear structure phenomena. Recent RQRPA calculations show a low-lying dipole mode for proton-rich argon isotopes. We performed a radioactive beam experiment in inverse and complete kinematics at GSI, applying the coulomb dissociation method on proton-rich Argon isotopes. The isotopes ^{32,34}Ar and other isotopes with similar A/Z ratio, like ^{31,32}Cl, were produced via fragmentation of a primary ^{36}Ar beam at 825 AMeV and subsequently directed onto a ^{208}Pb target, situated

at the LAND/R^3B setup. Because of the exclusive measurement of all particles it is possible to derive inclusive reaction cross sections and to study in detail the momentum distributions and energy-differential cross sections.

Basic analysis concepts and first inclusive (γ, p) cross sections will be presented.

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