

HK 36: Kern- und Teilchen-Astrophysik

Zeit: Donnerstag 16:30–19:00

Raum: 2B

Gruppenbericht

HK 36.1 Do 16:30 2B

Status and perspectives of the LUNA experiment at Gran Sasso/Italy — •DANIEL BEMMERER¹, RALF KUNZ², MICHELE MARTA¹, CLAUS ROLFS², FRANK STRIEDER², and HANNS-PETER TRAUTVETTER² for the LUNA-Collaboration — ¹Forschungszentrum Dresden-Rossendorf, 01328 Dresden, Germany — ²Institut für Experimentalphysik III, Ruhr-Universität Bochum, Bochum, Germany

The Laboratory Underground for Nuclear Astrophysics (LUNA) in the Gran Sasso underground facility, Italy, has been designed to measure low cross sections for astrophysical purposes. The ${}^3\text{He}(\alpha,\gamma){}^7\text{Be}$ study at LUNA has now been completed, and the final data will be shown here. During the year 2007, two measurement campaigns have been performed: First, a precision study of ground state capture in the ${}^{14}\text{N}(\text{p},\gamma){}^{15}\text{O}$ reaction with an impact on solar ${}^{13}\text{N}$ and ${}^{15}\text{O}$ neutrinos (contribution by M. Marta). Second, a study of the ${}^{25}\text{Mg}(\text{p},\gamma){}^{26}\text{Al}$ reaction producing radioactive ${}^{26}\text{Al}$, a tracer of live nucleosynthesis in our galaxy (contribution by F. Strieder).

The scientific program for the next years at the current LUNA 400 kV accelerator includes the study of the ${}^2\text{H}(\alpha,\gamma){}^6\text{Li}$ reaction for big-bang nucleosynthesis and the study of the ${}^{15}\text{N}(\text{p},\gamma){}^{16}\text{O}$ reaction and several other reactions of the CNO cycles. Feasibility studies on selected cases will be presented.

The scientific program for the proposed new LUNA 3 MV accelerator will be discussed.

Gruppenbericht

HK 36.2 Do 17:00 2B

Progress in determining keV neutron cross sections with AMS — •IRIS DILLMANN^{1,2}, ANTON WALLNER³, GEORG RUGEL², LAURENT COQUARD⁴, STEPHAN WALTER¹, FRANZ KÄPPELER¹, OLIVER FORSTNER³, ROBIN GOLSER³, ALFRED PRILLER³, PETER STEIER³, THOMAS FAESTERMANN², KLAUS KNIE⁵, GUNTHER KORSCHINEK², and MICHAEL POUTIVSEV² — ¹Institut für Kernphysik, Forschungszentrum Karlsruhe, Postfach 3640, D-76021 Karlsruhe — ²Physik Department, Technische Universität München, D-85747 Garching — ³Vienna Environmental Research Accelerator, Institut für Isotopenforschung und Kernphysik, Universität Wien, A-1090 Wien — ⁴Technische Universität Darmstadt, Institut für Kernphysik, D-64289 Darmstadt — ⁵Gesellschaft für Schwerionenforschung, D-64291 Darmstadt

This status report deals with the progress in the measurements of keV-neutron cross sections with a combination of the activation technique and accelerator mass spectrometry. The neutron activations were done at the Karlsruhe 3.7 MV Van de Graaff accelerator using the ${}^7\text{Li}(\text{p},\text{n}){}^7\text{Be}$ neutron source, and the subsequent AMS measurements performed at the VERA facility in Vienna and the Maier-Leibnitz laboratory in Munich. The (n,γ) cross sections of ${}^9\text{Be}$, ${}^{13}\text{C}$, ${}^{235}\text{U}$, and the ${}^{14}\text{N}(n,p)$ reaction were activated with a quasi-stellar neutron distribution of $kT=25$ keV and with monoenergetic neutron beams of 140, 220, and 500 keV. Further (n,γ) measurements on ${}^{35}\text{Cl}$, ${}^{40}\text{Ca}$, ${}^{54}\text{Fe}$, ${}^{58,62}\text{Ni}$, and ${}^{78}\text{Se}$ were performed at $kT=25$ keV and will be compared to previous TOF measurements.

HK 36.3 Do 17:30 2B

Messung der niederenergetischen Resonanzen der Reaktion ${}^{25}\text{Mg}(\text{p},\gamma){}^{26}\text{Al}$ — •FRANK STRIEDER¹, RALF KUNZ¹, HANNS-PETER TRAUTVETTER¹, CLAUS ROLFS¹, DANIEL BEMMERER² und MICHELE MARTA² für die LUNA-Kollaboration — ¹Institut für Physik mit Ionenstrahlen, Ruhr-Universität Bochum, Germany — ²Forschungszentrum Dresden-Rossendorf, 01328 Dresden, Germany

Die Kernreaktion ${}^{25}\text{Mg}(\text{p},\gamma){}^{26}\text{Al}$ ist die langsamste Reaktion des Mg-Al-Zyklus und verantwortlich für die Produktion des radioaktiven Isotops ${}^{26}\text{Al}$. Der Grundzustand von ${}^{26}\text{Al}$ zerfällt über einen β^+ -Zerfall oder Elektroneneinfang in den ersten angeregten Zustand von ${}^{26}\text{Mg}$, der wiederum über die Emission eines 1.809 MeV γ -Quants in den Grundzustand übergeht. Diese γ -Strahlung kann mit Satelliten-Teleskopen beobachtet werden, wodurch man Informationen über die Art der galaktischen Produktionsstätten des ${}^{26}\text{Al}$ erhält und somit auch Hinweise auf die astrophysikalischen Szenarien.

Im Rahmen der LUNA Kollaboration wurden die astrophysikalisch relevanten Resonanzen der Reaktion ${}^{25}\text{Mg}(\text{p},\gamma){}^{26}\text{Al}$ bis zur Energien unterhalb von 100 keV über Gammaskopie mit verschiedenen Detektoren im Gran Sasso Untergrundlabor gemessen und die Resonanzstärken bestimmt. Dabei wurde die niederenergetische Resonanz

bei $E_{cm} = 93$ keV zum erstenmal direkt beobachtet. Die Ergebnisse des Experimentes und die astrophysikalischen Auswirkungen werden in diesem Vortrag diskutiert.

Diese Projekt wird unterstützt von der Deutschen Forschungsgemeinschaft (DFG-Ro429/41)

HK 36.4 Do 17:45 2B

Microscopic calculation of phase shifts and astrophysical S-factors using fermionic molecular dynamics — •ROBERT CUSONS — Gesellschaft für Schwerionenforschung, Planckstr. 1, 64291 Darmstadt, Germany

Scattering states have been calculated in a microscopic and unified way using Fermionic Molecular Dynamics. The realistic Argonne-V18 interaction was transformed into a phase shift equivalent effective interaction, V_{UCOM} , by using the Unitary Correlation Operator Method to include short range correlations. Both ground states of the nuclei in the incoming and outgoing channels and the phase shifts were calculated microscopically for the elastic scattering reactions: ${}^4\text{He}(n,n){}^4\text{He}$ and ${}^3\text{He}(\alpha,\alpha){}^3\text{He}$. The S-factor for the reaction ${}^3\text{He}(\alpha,\gamma){}^7\text{Be}$, which is of astrophysical interest in the ppII chain, is compared to data.

HK 36.5 Do 18:00 2B

Precision study of the ${}^{14}\text{N}(\text{p},\gamma){}^{15}\text{O}$ reaction at LUNA — •MICHELE MARTA¹, DANIEL BEMMERER¹, RALF KUNZ², CLAUS ROLFS², FRANK STRIEDER², and HANNS-PETER TRAUTVETTER² for the LUNA-Collaboration — ¹Forschungszentrum Dresden-Rossendorf, 01328 Dresden, Germany — ²Institut für Experimentalphysik III, Ruhr-Universität Bochum, Bochum, Germany

The rate of the hydrogen-burning CNO cycle is controlled by the slowest reaction, ${}^{14}\text{N}(\text{p},\gamma){}^{15}\text{O}$. 15-30% of the total cross section are contributed by radiative capture to the ground state in ${}^{15}\text{O}$. Previous extrapolated S-factors for this ground state contribution disagree by a factor 2. The precision of those previous studies had been limited by a sizable true coincidence summing correction. In a new experiment using a segmented Clover detector deep underground at LUNA, the summing correction has been reduced by a factor 30, so existing R-matrix fits can now be precisely tested. The present data enable a direct measurement of the metallicity at the center of the Sun by detecting solar CNO neutrinos, for example at Borexino.

HK 36.6 Do 18:15 2B

The Study of ${}^3\text{He}(\alpha,\gamma){}^7\text{Be}$ with a Recoil Separator — •ANTONINO DI LEVA^{1,2}, RALF KUNZ¹, CLAUS ROLFS¹, FRANK STRIEDER¹, and LUCIO GIALANELLA² — ¹Institut für Physik mit Ionenstrahlen, Ruhr-Universität Bochum, Germany — ²INFN Napoli, Italy

The ${}^3\text{He}(\alpha,\gamma){}^7\text{Be}$ reaction plays an important role in the interpretation of the solar neutrino experiments, since the estimate of the total neutrino flux relies on the solar neutrino spectrum, calculated by solar models. The high energy component in this spectrum is mainly produced by the decay of ${}^7\text{Be}$ and ${}^8\text{B}$. Moreover, the uncertainty in the ${}^3\text{He}(\alpha,\gamma){}^7\text{Be}$ cross section is one of the largest uncertainty in the predicted primordial ${}^7\text{Li}$ abundance in Big Bang Nucleosynthesis calculations.

Previous measurements of the ${}^3\text{He}(\alpha,\gamma){}^7\text{Be}$ cross section have been performed detecting the capture γ -rays or, alternatively, measuring the activity of the synthesized ${}^7\text{Be}$. An alternative approach uses the ERNA recoil separator at the 4MV tandem accelerator at the Ruhr-Universität Bochum to detect directly the ${}^7\text{Be}$ reaction products and, additionally, the coincident detection of the capture γ -rays. The results of this experiment are presented and compared with literature values.

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HK 36.7 Do 18:30 2B

R-Matrix-Fits an totale Wirkungsquerschnittsdaten der Reaktion ${}^{12}\text{C}(\alpha,\gamma){}^{16}\text{O}$ — •RALF KUNZ¹, KATRIN FORTAK¹, ANTONINO DI LEVA¹, LUCIO GIALANELLA², DETLEF ROGALLA¹, CLAUS ROLFS¹, DANIEL SCHÜRMAN¹ und FRANK STRIEDER¹ — ¹Institut für Experimentalphysik III, Ruhr-Universität Bochum, Deutschland — ²Dipartimento di Scienze Fisiche, Università di Napoli and INFN Napoli, Italy

Die Beschreibung der mit dem Europäischen Rückstoßseparator für

Nukleare Astrophysik (ERNA) gewonnenen Daten zum totalen Wirkungsquerschnitt der für das Heliumbrennen der Sterne relevanten Reaktion $^{12}\text{C}(\alpha, \gamma)^{16}\text{O}$ mit der R -Matrix-Methode wird vorgestellt. Hierzu werden der $E1$ -, $E2$ - und sämtliche Kaskadenbeiträge, inklusive dem Übergang in den ersten angeregten 0^+ -Zustand, berücksichtigt. Weiterhin werden zusätzlich Daten aus der elastischen Streuung und aus dem β -verzögerten α -Zerfall von ^{16}N verwendet. Dabei wird eine Art der Parametrisierung verwendet, die es erlaubt einen einheitlichen Parametersatz für alle Anteile zu benutzen, und nicht durch das Experiment zugängliche Zustände durch Literaturwerte zu beschreiben. Der Formalismus für den γ -Capture beinhaltet ebenfalls einen Beitrag durch den Direct Capture.

Die Schwierigkeiten in der Beschreibung werden dargestellt, und ein Ausblick auf ein weiteres Experiment zur Gewinnung zusätzlicher Informationen mit einem Jet-Gastarget an ERNA wird gegeben.

HK 36.8 Do 18:45 2B

Parity Dependent Nuclear Level Densities in Hauser-Feshbach Calculations for Stellar Reaction Rates — •HANS PETER LOENS¹, GABRIEL MARTÍNEZ-PINEDO¹, KARLHEINZ LANGANKE¹, FRIEDRICH-KARL THIELEMANN², and THOMAS RAUSCHER² —

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The statistical Hauser-Feshbach model is used to obtain reaction rates that are being used in nucleosynthesis simulations. The necessary nuclear level densities (NLD) have been calculated with equipartitioned parities. However, newer theoretical calculations [1-4] and as well as experimental investigations [4] show that the assumption of equipartitioned parities within the NLD is not generally true up to rather high energies.

We calculated (n, γ) -reaction-rates - that are necessary for r-process modelling - with a parity dependent level density and developed a simple model to introduce a parity dependence for the compound nucleus. Our investigations clearly show that the new treatments can have an influence on the reaction rate itself. Moreover, we studied the combination of our new parity treatment with microscopical results (pygmy resonances) of γ -strengths for certain nuclei.

[1] H. Nakada and Y. Alhassid in Phys. Rev. Lett. 79, 2939 (1997)

[2] S. Hilaire and S. Goriely in Nucl. Phys. A 776, 63-81 (2006)

[3] D. Mocolj et al. in Phys. Rev. C 75, 045805 (2007)

[4] Y. Kalmykov et al. in Phys. Rev. Lett. 99, 202502 (2007)