Nuclear Reactions

Adelaide Pedro de Jesus

This group has been involved in the experimental study of nuclear reactions relevant to nuclear astrophysics and also to ion beam analytical techniques.

The on-going work is related to the development of the AMS line to study reactions relevant to nuclear astrophysics.

Also a new line has been installed in the new Tandem 3MV accelerator, for nuclear reaction studies both for fundamental nuclear physics and nuclear astrophysics and for applied PIGE work.

Research Team

Researchers

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Experimental Study of Nuclear Reactions for Astrophysics

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Objectives

Following its experimental work in nuclear reactions relevant for primordial and stellar nucleosynthesis (hydrogen burning), the group is focusing now in later stages of stellar nucleosynthesis, namely alpha, carbon and oxygen burning and p-process. Some of the studies will proceed within international collaborations, making use of facilities such as ERNA, FAIR, ISOLDE. Other studies will be conducted at ITN, taking advantage of the heavy ion beams available at the 3 MV Tandem accelerator and of the accelerator mass spectrometry (AMS) line.

Results

During this year, the optimization of the AMS line for detection and quantification of ^{36}Cl was initiated. ^{36}Cl is one of several short to medium lived isotopes (as compared to the earth age) whose abundances at the earlier solar system may help to clarify its formation process. There are two generally accepted possible models for the production of this radionuclide: it originated from the ejecta of a nearby supernova (where ^{36}Cl was most probably produced in the s-process by neutron irradiation of ^{35}Cl) and/or it was produced by in-situ irradiation of nebular dust by energetic particles (mostly, p, α, ^{3}He -X-wind irradiation model).

The Accelerator Mass Spectrometry (AMS) technique has gained international reputation as the technique to detect and quantify rare isotopes as ^{14}C, ^{10}Be, ^{26}Al, ^{36}Cl and many others, that are continuously being produced by cosmic radiation, being very useful as geochronometers, as probes of production and evolution of geological formations and of environment and climate changes, also useful for dating and model cosmic radiation and solar activities.

Future Work

During 2011, cross sections of neutron capture by ^{35}Cl and (p,d) and (d,p) reactions on ^{37}Cl and ^{35}Cl will be obtained.

Development of a PIGE Set-up

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Objectives

The aim of this work is the extension to all light elements of previous work, in order to install an analytical set-up for light element analysis, based on the detection of the gamma radiation induced by low energy protons, PIGE.

This technique will open new perspectives of applied work in environment and health problems.

Results

A precise method based on a code [1] that integrates the nuclear reaction excitation function along the depth of the sample was implemented for thick and intermediate samples. For that purpose some reaction excitation functions were measured in the same analytical conditions. The energy steps needed to define accurately the excitation function were used as energy intervals for the integration procedure.

Previous results obtained at the Van de Graaff accelerator on ^{25}Mg(p,p'gamma)^{25}Mg with proton energies up to 2.4 MeV and ^{9}Be(p, gamma)^{10}B were analysed and published [2].

The nuclear reactions ^{10}B(p,alpha gamma)^{7}Be, ^{23}Na (p,p'gamma)^{23}Na, ^{19}F(p,p'gamma)^{19}F, ^{7}Li(p,p'gamma)^{7}Li and ^{25}Mg(p,p'gamma)^{25}Mg were measured up to 4.0 MeV at the 3 MV Tandem accelerator at ITN. Also some applications of PIGE were performed, namely for studying ceramic glazes [3].

Future work

The group has submitted a three year project within a IAEA Co-ordinated Research Project (CRP) on "Assessment of Nuclear Data Needs for Particle Induced Gamma Ray Emission (PIGE)", that has been accepted.

References

[1] R. Mateus, A. P. Jesus, J. P. Ribeiro, Nucl. Inst. and Meth. B229, 302-308 (2005)
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[3] M. Fonseca, H. Luís, N. Franco, M. A. Reis, P. C. Chaves, A. Taborda, J. Cruz, D. Galaviz, N. Fernandes, P. Vieira, J.P. Ribeiro, A.P. Jesus; Accepted to Nucl. Instr.& Meth. B