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ABSTRACT : The first experiments made at GANIL with the neutron detector Demon are described and their preliminary results presented.

I - The neutron detector DEMON

DEMON has been built by a belgian-french collaboration to be used in heavy ion collisions at intermediate energies (a few tens of MeV per nucleon) [Ref. 1]. It is made of 98 detectors ; each detector is a cylinder (20 cm long , 16 cm in diameter) filled of Ne213 liquid scintillator and viewed by a phototube. A thin plastic scintillator placed in front of the cylinder and viewed by another phototube (Fig. 1) allows for charge particle rejection. The neutron/gamma ray discrimination is achieved by a shape analysis of the signal produced in the liquid scintillator (Fig. 2). The neutron energy is obtained via a time of flight measurement on the distance of around 2 meters between the target and the detector (the start signal is the RF signal of the accelerator, the stop signal is delivered by the detector).

The neutron detection efficiency, calculated using a simulation [Ref. 2], of each detector decreases from around 60% at a few MeV, down to 30% for 100 MeV neutrons. Experimental results obtained by three different methods [Ref. 3, 4, 5] are in excellent agreement with the calculation (Fig. 3).

After a first experiment at Louvain-La-Neuve (Belgium), [Ref. 6] Demon moved to GANIL in summer 1994 for a series of experiments [Ref. 7]. We will describe here two of these experiments and present their preliminary results.

Figure 1
Detail of a Demon cell

Figure 2
An example of neutron/ γ discrimination

Figure 3
Neutron detection efficiency

Figure 4
experimental arrangement for the residue experiment

II - Limit of existence of hot residues formed in the 60 MeV Ar+Au reaction

Hot nuclei can decay by different ways : fission, fragmentation, light particle evaporation. The relative importance of these various decay channels as a function of the excitation energy is not well established [Ref. 8]. In particular, the limits of existence of hot nuclei as their excitation energy or their temperature increases are not well known.

The purpose of the experiment was to use the neutron energy distributions to determine the temperature of the hottest residues emitted in the reaction. The residues were detected and identified in a telescope of solid state detector located in forward direction (actually two telescopes were used to increase the statistics). The discrimination between residues and fission fragments was achieved using in anticoincidence with the telescope a parallel plate avalanche counter (PPAC) located at backward angles. The 98 counters of Demon, regularly disposed, surrounded the target at a distance of 1.75 meters (Fig. 4).

An example of mass/velocity diagram of heavy nuclei detected by a telescope is given in Fig. 5. The PPAC rejected most of the fissions but not all : a small contribution of the fission branch remains which was eliminated by a cut in the mass velocity diagram (Fig. 5-c). The low velocity threshold is due to the RF structure of the accelerator. Only masses $A \geq 40$ have been represented in figure 5, in order to eliminate most of the products originating from the projectile fragmentation. The mass was obtained through the energy measurement. Special care was given to the correction of the pulse height defect (PHD). The PHD was accurately measured using low energy elastic collisions 4.5 MeV Ar + (Ag, Au, Ho) : the deflected projectile was detected in a PPAC and the deflected target in a telescope, the measured energy of the deflected target was compared to its real energy deduced from the kinematics.

The energy distribution of the neutrons detected in coincidence with a residue, in the rest frame of this residue, can be fitted by an exponential, whose slope is an estimation of the temperature T of the residue. Preliminary results on the evolution of T with the velocity of the residue are presented in Fig. 6. It can be seen that temperatures of ~ 6 MeV are reached for the hottest residues (which lead, of course, to the largest velocities). Of course, these first results have to be considered with caution:

- the effect on T of the experimental uncertainties has not been evaluated
- T is the apparent temperature averaged all along the neutron emission chain, not the initial temperature

- the mass in Fig. 5 is the final mass of the residue, not the initial one.

Some work is still needed before reaching our final goal which is the estimation of the production cross section and of the initial temperature of the residues as a function of their initial mass.

Figure 5

Velocity/mass diagram for fragments
detected in one of the telescopes

Figure 6

III - Neutron angular distributions from the break up of ^{19}C

For some light, weakly bound neutron rich nuclei, the valence neutron(s) extends farther from the nucleus than expected from systematics : they form a halo [Ref. 9]. Until now, most investigations have concentrated on ^{11}Li and ^{11}Be . At Ganil we have undertaken a study of the ^{19}C which is a good candidate for a neutron halo as the binding energy of the single neutron is only $\epsilon = 160 \text{ KeV}$.

A secondary beam of ^{19}C was obtained via the reaction of a $70 \text{ MeV/A } ^{40}\text{Ar}$ beam with a Carbon target located in the SSISS facility. The reaction products were collected and separated using a magnetic spectrometer. The identification of the incoming beam particles was provided by a thin Si detector ($\Delta E/\text{time of flight}$) located in the reaction chamber (Fig. 7).

Figure 7
 ^{19}C identification

The intensity of the ^{19}C beam was of 10 to 25 nuclei per second. It reacted with a thick tantalum target (531 mg/cm²) and the charge reaction products were detected around zero degrees and identified using a large area position sensitive silicon detector telescope.

The neutrons were detected using the 98 elements of the Demon array located in a close packed forward geometry (Fig. 8), 4.5 m downstream of the tantalum target.

Several hundreds of events have been obtained corresponding to neutrons detected in coincidence with charged products originating from the break up of the ^{19}C nucleus (core target reaction). The preliminary neutron angular distributions for core target reactions are compared in Fig. 9 for various projectiles : ^{19}C , ^{21}N , ^{22}O , ^{24}F . For the last three nuclei no neutron halo is expected and a gaussian fit of the neutron angular distribution leads to a width Δp of around 160 MeV/c for the momentum distribution of the neutrons in the nucleus. In the case of ^{19}C , two gaussian contributions are needed to fit the angular distributions : the first one with $\Delta p \sim 190$ MeV/c corresponds to "normal" neutrons in the ^{19}C nucleus, the second one with $\Delta p = 49$ MeV/c is responsible for the forward peaking in the angular distribution and is characteristic of a halo distribution.

Figure 8

Experimental set up for neutron halo experiment

Figure 9

Angular distributions of neutrons emitted in various reactions

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