REVISTA MEXICANA DE FÍSICA S53 (3) 49–51 FEBRERO 2007

Initial results of the mexican participation in the Alpha Magnetic Spectrometer Project

E. Belmont-Moreno, A. Menchaca-Rocha, A. Sandoval, R. Alfaro, A. Martínez-Dávalos, and V. Grabski
Instituto de Fisica, Universidad Nacional Autónoma de México
Apartado Postal 20-364, 01000 México D.F., México.

Recibido el 2 de marzo de 2006; aceptado el 18 de agosto de 2006

Mexico is part of the AMS (*Alpha Magnetic Spectrometer*) project, consisting of several radiation detectors integrated in a single telescope to be sent to the outer space in search of antimatter. One of those detectors is a RICH (Ring Imaging Cherenkov), where the cosmic particle's speed is calculated from the Cherenkov light-rings observed. The IF-UNAM group works in characterizing the silica aerogel used as luminous element in this detector. Because the spectrometer will be in orbit for several years, some particular studies are necessary. Our group works on possible ageing mechanisms, showing that the main threat to this material is contamination rather than thermal, or vacuum, shocks.

Keywords: AMS; RICH: aerogel.

México es parte del proyecto AMS (*Alpha Magnetic Spectrometer*) que está constituido por varios detectores de radiación integrados en un telescopio que será enviado al espacio exterior en búsqueda de antimateria. Uno de los detectores es de tipo RICH (Ring Imaging Cherenkov), donde se calcula la velocidad de las partículas cósmicas a partir de los anillos de luz Cherenkov. El grupo del IF-UNAM trabaja en la caracterización del aerogel de sílica que se usa como elemento luminoso en este detector. Como el espectrómetro estará en orbita varios años, son necesarios algunos estudios específicos. Nuestro grupo estudia los posibles mecanismos de añejamiento, mostrando que la mayor amenaza a este material es la contaminación más que los choques térmicos, o de vacío.

Descriptores: Espectrómetro magnético alfa; detector RICH; aerogel.

PACS: 78.20.Ci

1. Introduction

The Alpha Magnetic Spectrometer, AMS, was proposed to the international community in 1995 [1] by Samuel Ting, Nobel Laureate 1976. It is intended as a tool in the search for antimatter from the outer space. México was invited to participate some time later, specifically to collaborate in the construction of the RICH detector. The physics involved in AMS is the identification on primary antimatter nuclei. Cosmic radiation traveling through space interacts with the solar wind and the interstellar medium, generating nucleons and antinucleons nuclei and antinuclei, although there exist a small probability for the creation of light nuclei (other than protons), which is an exponentially decreasing function of their mass. The probability for detecting a secondary deuteron in the 3 years of AMS flight is very low, and practically impossible to detect heavier antinuclei. Thus, if we detect antihelium it can be taken as evidence for the existence of antistars.

The AMS had a first stage where a prototype was flown on the NASA Space Shuttle Discovery, on its STS-91 mission, which took place in June 1998. This was a test flight to gather data on background sources, to adjust operating parameters, and to verify the detector's performance under actual space flight conditions. A first search for antihelium nuclei using data colleted during this precursor flight was reported in [2,3]. The final stage, labeled AMS-II, is currently under integration, and is expected to be flown by NASA some time before 2010.

A Schematic cross section of AMS is given in Fig. 1, which shows the magnet and the different detectors. The magnet provides the analyzing power of the spectrometer. For velocity measurement, at he lower part, outside of the magnetic field, is the RICH detector having silica aerogel as radiator. The whole system will be installed on the International Space Station (ISS) and will take data for several years (at least 3). The information from the different detection systems will be analyzed to identify unambiguously the particles it encounters.

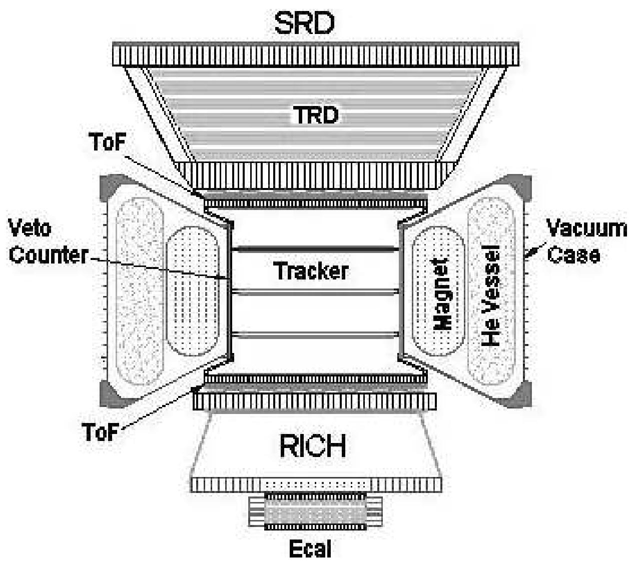

FIGURE 1. AMS schema. **SRD** Synchrotron Radiation Detector, **TRD** Transition Radiation Detector, **TOF** Time Of Flight system, Tracker detector, Veto Counter, **RICH** Ring Imaging CHerenkov detector, **Ecal** Electromagnetic calorimeter.

After the test flight, studies to determinate which aerogel would be used to construct the final RICH were started. Two manufacturers were considered as likely aerogel providers: Matsushita Electric Works and the Novosibirsk Catalysis Institute. Those studies were necessary not only to choose the aerogel but also to understand an anomalous behavior appearing during the first flight. Then, it was noticed that the Cherenkov luminosity of the silica aerogel suffered degradation. From the first value in a test made at ground to the value at fly, the luminosity decreased by 40%. Back at the laboratory it appeared to be down by another factor of 2 during a CERN test in November 1998 [4]. The Mexican team was then invited to characterize the optical properties of the aerogel, and to perform ageing tests. The first set of optical tests was performed on Matsushita samples, which was reported in [5,6]. The ageing test is currently under way, and is necessary to determine if the vacuum and temperature cycle to which the AMS is subject, affects the optical properties. In space the material is in almost perfect vacuum while undergoing a fast temperature variation of nearly 100°C, from direct sun exposition to Earth's shadow. Here we report on the ageing tests.

2. Measurement

The main optical characteristics measured on the aerogel were: absorbance, luminescence, refraction index, dispersion law, as well as sample uniformity. Those measurements were reported in due time. The ageing process, on the other hand, requires several measurements along a time period. As the AMS will be in space several years the ageing test is made for a rather long time span. The test consists on subjecting the aerogel to vacuum and thermal cycles. The experimental set up (see Fig. 2) consists of a small cylindrical cell (1) made out of stainless steel 10 cm long by 5 cm diameter. The cell is connected to a cryosorption pump system (2). Outside the cell, two coils are placed in mechanical contact with the aerogel sample, one for heating through an electric residence (5) and other for cooling purposes (6), using a standard CFC system (8) to complete the needed thermal cycle. Also attached, outside, a thermocouple (4) is used to register the temperature. One sample of aerogel is placed inside the cell, located inside a Stainless Steel box, having an adequate window to allow optical measurements (1a). The aerogel is gently fixed *in situ* using glass-wool for padding, as the aerogel is extremely brittle. The cell is evacuated to 10^{-3} Torr and a thermal cycle 0°C-100°C, having a one hour period, is started. The optical transmission is measured with a Milton Roy 3000 spectrophotometer approximately each month.

3. Results

The clarity C results from a fit to the measured transmission curve T (see Fig. 3) using the Hunt formula,

$$T(\lambda) = A\exp(-Ct/\lambda^4) \tag{1}$$

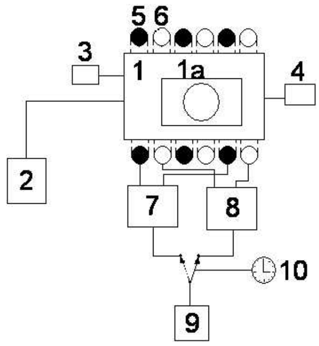

FIGURE 2. Experimental Set Up: (1) Test cell, (1a) sample cage with window, (2) Cryosorption pump, (3) vacuum meter, (4) temperature meter (thermocouple), (5) Heating coil, (6) cooling coil, (7) Heating power supply, (8) Cooling system, (9) line supply, (10) clock activate switch.

were t represents the aerogel thickness, A is an absorption coefficient, and is λ the wave length of the used light. The clarity is given in units of μm^4/cm. During measurements, different vacuum systems were used this turned out to be the determining factor affecting clarity. We detected contaminating fumes from: the rotary vane pumps, the aluminum parts of the vacuum system, the vacuum grease, and the rubber o-rings used as sills, which turned out to rapidly contaminate the samples. Hence, all other potential fume-emitters were eliminated from the vacuum compartment housing the aerogel. It was noticed that, while at vacuum, aerogel is much more prone to catch fumes and odors than at atmospheric pressure. Seemingly harmless materials at air pressure [7] become dangerous at vacuum when heated. This lead us to propose two possible reasons for the trouble with aerogel during AMS-I: a) contamination with fumes of any nearby material in the AMS, and b) contamination at ground when AMS was tested in vacuum chambers. This suggest that: a) AMS should be built out of heat-stable materials, and b) vacuum tests should be carried out in odorless/fumeless vacuum systems.

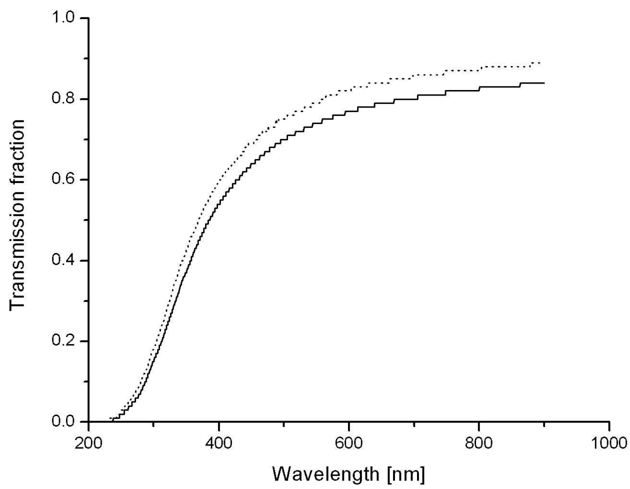

FIGURE 3. Aerogel transmission curve from UV to IR.

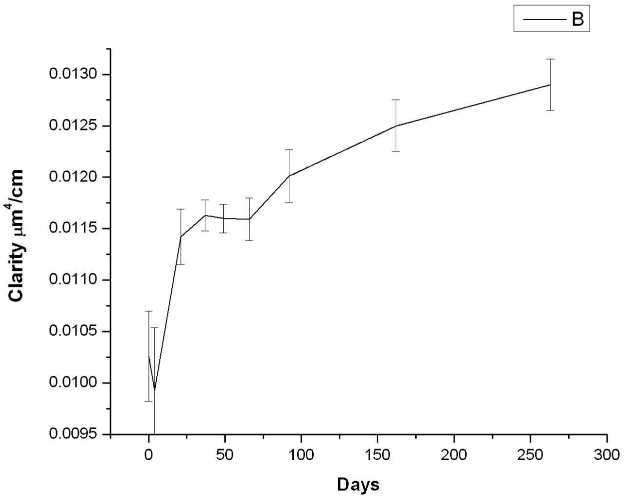

FIGURE 4. Evolution of Clarity C in time, note a primary decrease of clarity (by degasification or loose of humidity) and a posterior asymptotic stabilization in higher value.

In Fig. 4 we show the behavior of the clarity as function of time, where an initial increase in C occurs which tends to stabilize at longer times. As the experiment was carried out for more than a year, we feel confident to conclude that no serious deterioration due to thermal cycle in vacuum at later times. This behavior approximately agrees with observations by Italian and Spanish AMS collaborators, carried out comparable criteria [8,9].

4. Conclusions

The tests applied to aerogel radiators show a high sensitivity of this material to contamination by residual fumes and odors present in standard vacuum systems. Contamination occurs within a rather short time scale. When vacuum and thermal cycle tests are carried out, carefully eliminating possible contamination sources, the effect is clarity observed is a rapid initial increase followed by a long term stabilization.

Acknowledgements

We wish to thank Hector Cruz Manjarrez for his collaboration.

1. S.C.C. Ting, Phys. Rep. **279** (1997) 203.
2. AMS Collaboration, Phys.Lett B **461** (1999) 387.
3. AMS Collaboration, Phys.Rep. **366** (2002) 331.
4. M. Buenerd and T.Thuillier, AMS Internal note. ISN Grenoble 99/122, 8 Nov. 1999.
5. M. Villoro et al., Nucl. Inst. Meth. A **480** (2002) 456.
6. A.Martinez-Davalos et al. Nucl.Inst.Meth. A **553** (2005) 177.
7. A.K.Cougas et al. Nucl.Instr.Meth. A **421** (1999) 249.
8. Mariane Brinet, private communication.
9. CIEMAT group, Madrid, private communication.