Search for Strange Matter by Heavy Ion Activation

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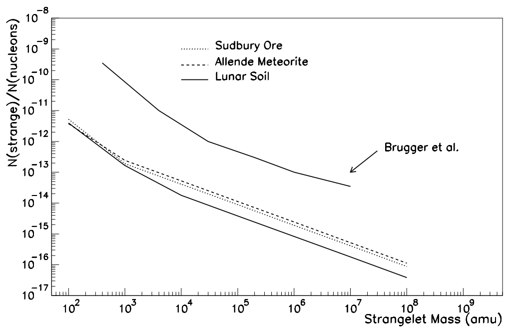
It is possible that strange matter (aggregates of up, down, and strange quarks) exists and that it is absolutely stable. If this is the case, strange matter would be the true ground state of the strong interaction.

We present the results of a search performed at LBNL's 88-Inch Cyclotron using GAMMASPHERE in which we probed the strange matter contents in normal matter by heavy ion activation. The previous experimental limit on the strange matter content in normal matter was improved by 3 to 4 orders of magnitude. We also established a limit on the flux of low mass nuclearites on the lunar surface.

The extra binding energy and the beam kinetic energy in the interaction of a normal nucleus with strange matter will excite the strange nucleus and raise its temperature, which characterizes a spectrum of photons released by the de-excitation of the strange nucleus. The strange nucleus will emit many low energy photons, with an average energy of T, in a photon "burst". We chose to run with a beam of ^{136}Xe at 450 MeV, delivered at high current by the 88-Inch Cyclotron at Lawrence Berkeley National Laboratory (LBNL). In our search, we examined one sample of nickel ore found at 2070 m underground [1], one sample of the Allende meteorite [2] and one sample of lunar soil collected in the Apollo 17 mission [3]. In figure 1 we plot the limits obtained for strange matter content in the three samples analyzed, and compare them with the previous limit by Brügger et al [4].

Our experiment was mostly sensitive to light nuclearites, with masses below $A = 10^9$, which, if present as cosmic rays, would be absorbed in the Earth's atmosphere. Since the Moon has no atmosphere and its surface has been exposed for millions of years, the upper limit in concentration of strange matter in the lunar soil allows us to derive a limit for the flux of nuclearites impinging the surface of the Moon. The observation of high cosmic ray track densities in the lunar sample 78481 indicates that the integrated lunar surface exposure age is of the order of 100 My [5]. Our experiment severely restricts the fraction of dark matter in the galaxy that could be in the form of low mass nuclearites.



Experimental limit on the concentration of nuclearites in our samples. The limits are based on the number of events which survive the cuts described in the text. The results from Brügger and collaborators obtained in an iron meteorite are also plotted for comparison.

References

[1] Creighton Mine, 6800 ft. level. Sudbury,Canada.

[2] USNM 3529, Smithsonian Institution.

[3] R. V. Morris, R. Score, C. Dardano and G. Heiken, Handbook of Lunar Soils, JSC 19069, PP. 914, Johnson Space Center, Houston, 1983.

[4] M. Brügger et al., Nature **337**, 434, 1989.

[5] J. N. Goswami and D. Lal, Proc. Lunar Sci. Conf. 5th, 2643, 1974.

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