PROCEEDINGS OF SCIENCE

ONLINE ICRC 2021
THE ASTROPARTICLE PHYSICS CONFERENCE
Berlin | Germany
37th International Cosmic Ray Conference
12–23 July 2021

Search for nuclearite with ANTARES

M. Bouta,[a,*] J. Brunner,[b] A. Moussa,[a] G. E. Păvălaş[c] and Y. Tayalati[d] on behalf of the ANTARES Collaboration
(a complete list of authors can be found at the end of the proceedings)

[a] *University Mohammed First in Oujda, 67600, Oujda, Morocco*
[b] *Centre de Physique des Particules de Marseille, France*
[c] *Institute of Space Science Măgurele, Romania*
[d] *University Mohammed V in Rabat, Morocco*
E-mail: boutamohammed@hotmail.com

ANTARES is a Cherenkov underwater neutrino telescope operating in the Mediterranean. Its construction was completed in 2008. Even though optimised for the search of cosmic neutrinos, this telescope is also sensitive to nuclearites (massive nuggets of strange matter) trough the black body radiation emitted along their path [1, 2].

We discuss here the possible detection of non-relativistic down-going nuclearites with the ANTARES telescope and present the results of an updated analysis using data collected from 2009 till 2017.

37th International Cosmic Ray Conference (ICRC 2021)
July 12th – 23rd, 2021
Online – Berlin, Germany

*Presenter

Executive summary

Strange quark matter (SQM) has been suggested to be the true ground state of hadronic matter [3]. SQM objects may be created by various astrophysical processes in the universe, and they may be contained in cosmic rays reaching the Earth in the form of nuclearites. At high enough energies ($\sim 10^{13}$ GeV$/c^2$), and by assuming a galactic velocities at the top of atmosphere, nuclearites may reach the ANTARES detector, a neutrino telescope operating from 2007 until now at the abbeys in the Mediterranean Sea [4].

Nuclearites are hypothetical heavy particles derived from the SQM Theory. They could be present in the cosmic radiation reaching the Earth originating from relics of the early Universe as nuggets or strange star collisions. These particles would be expected to have galactic velocities and could be identified by tracks seen in cosmic ray detectors based on the Earth. SQM Nuclearites of galactic velocities are protected by their surrounding electrons against direct interactions with the atoms constituting the traversed medium, and they would likely be neutral but would lose a large amount of energy by elastic and quasi-elastic collisions with atoms and molecules in their path and so leave distinct tracks in cosmic ray detectors. In the case of a transparent medium, nuclearites signal could be tracked by using their visible light emission as a black-body radiation from an expanding cylindrical thermal shock wave [2, 5].

In this work, we study cosmic nuclearites falling on the Earth with galactic velocities $\beta = 10^3$. A mass of 4×10^{13} GeV/c^2 was taken as a threshold mass for nuclearites detection at ANATRES level. By using dedicated Monte Carlo simulation software, we simulated these particles in ANTARES detector, atmospheric muons are the main source of background events. We present here, the results obtained for searching for cosmic nuclearites by using nine years of data taking by the ANTARES neutrinos telescope.

References

[1] V. Popa, *Very large volume neutrino telescopes as magnetic monopole and nuclearite detectors*. Nucl. Instr. & Meths. in Phys. Res. A 567 (2006) 480-482.

[2] A. De Rújula & S. L. Glashow *Nuclearites - a novel form of cosmic radiation*. Nature 312 (1984) 734; A. De Rújula Nucl. Phys. A434 (1985) 605.

[3] Edward Witten. *Cosmic separation of phases*. institute for advanced study, Princeton, New Jersey 08540, 1984

[4] J.A. Aguilar et al. *ANTARES: the first undersea neutrino telescope*. arXiv:1104.1607 [astro-ph.IM]

[5] Edward Farhi and R. L. Jaffe *Strange matter*. Center for Theoretical Physics, Laboratory for Nuclear Science and Department of physics, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139