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# Prospects for Miyun 50m Radio Telescope to Observe Radio Waves from UHE Neutrinos Interacting with the Lunar Regolith

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## Abstract

In the past decades, there have been several observations to detect UHE (Ultrahigh-Energy) neutrinos by searching for radio Cherenkov bursts resulting from impact showers in the lunar regolith. However, these observations have yielded no detection.

We plan to detect UHE neutrinos by the lunar Cherenkov technique using Miyun 50m radio telescope with a frequency range of 2.2-2.3 GHz. In this paper, we calculate the expected sensitivity for the observation, and study the possibility of detection of $10^{21}$ eV neutrino radio waves with the facility.

## 1. Introduction

The production and propagation of cosmic rays in the universe are usually accompanied by UHE neutrino production. The detection of cosmogenic UHE neutrinos is opening a new window beyond the electromagnetic observations [4]. UHE neutrino detection using the lunar Cherenkov technique aims to detect nanosecond radio pulses of Cherenkov emission which are produced during UHE neutrino interactions in the lunar regolith [1].

During the past decades, there have been several observations to detect UHE neutrino by the lunar Cherenkov technique using Earth-based radio telescopes at L and S-band. However, these attempts have yielded no detection [5].

For searches which use the Moon as a target, we intend to use the Miyun 50m diameter radio telescope of NAOC with a frequency range of 2.2-2.3 GHz. We calculate the expected sensitivity for the observation, and study the possibility of detection of UHE neutrino radio pulses with the facility.

## 2. Properties of the Radio Waves

In the absence of lunar regolith attenuation, the peak electric field strength of a lunar Cherenkov pulse received at an Earth-based radio telescope can be parameterized as [3][6]

$$\varepsilon^{c}{}_{\max}(E,\nu)=0.51\left[\frac{0.2E}{ZeV}\right]\left[\frac{\nu}{\nu_0}\right]\left[1+\left(\frac{\nu}{\nu_0}\right)^{\alpha}\right]^{-1}\mu Vm^{-1}MHz^{-1} \qquad (1)$$

where $\nu_0$ = 2.32 GHz, $\alpha$ = 1.23 for regolith material[6] and $\nu$ is the observation frequency.

However, the radio pulses will be strongly attenuated by the lunar regolith as it propagates to the surface from the shower interaction in the interior. The transmission can be approximated by a constant value t=0.6 without significant error [2]. The maximum free-space electric field strength can be written as

$$\varepsilon^{c}{}_{t}(E,\nu)=0.6\varepsilon^{c}{}_{\max}(E,\nu) \qquad (2)$$

For the Miyun 50m telescope search ($\nu_0$=2.25 GHz), the peak electric field of the Cherenkov pulse at the telescope, including regolith attenuation, is

$$\varepsilon^{c}{}_{t}(E)=0.030\left[\frac{E}{ZeV}\right]\mu Vm^{-1}MHz^{-1} \qquad (3)$$

## 3. Signal-to-Noise Ratio

To detect the radio waves, the electric field given by Equation (2) must reach the minimum receiver sensitivity of the radio telescope. The RMS field due to receiver noise fluctuations is parameterized as

$$\varepsilon^{d}=\left(\eta\frac{k_b T_{sys} Z_0}{A_e \Delta\nu}\right)^{\frac{1}{2}} \qquad (4)$$

where η is a constant which depends on the telescope feed and radiation, $k_b$ is the Boltzmann's constant, $A_e$ is the effective area of radio telescope, $T_{sys}$ is system temperature, and $Z_0 = 377\Omega$ is the impedance of free space.

For a given detector scheme, the minimum detectable electric field is a multiple $N_\sigma$ of the RMS field given by the detection threshold. This evaluates to

$$\varepsilon^{t}_{\min} = N_\sigma \cdot \varepsilon^{d} \quad (5)$$

For Miyun 50m telescope search, ($N_\sigma$=4, η=2, $T_{sys}$=247K pointing on the lunar, $A_e$ = 1001 $m^2$, $\Delta\nu$ =100MHz) this evaluates to

$$\varepsilon^{t}_{\min} = 0.020\mu Vm^{-1}MHz^{-1} \quad (6)$$

## 4. Summary and Conclusions

The potential for Miyun 50m telescope to detect UHE neutrinos through their radio pulse emission produced when showering in the lunar regolith has been calculated. By equating equations (3) and (6), we find that the minimum detectable incident neutrino energy for Miyun 50m telescope in 2.2-2.3 GHz is $E_{min}$ = 0.67 ZeV.

The result indicates that Miyun 50m telescope has the possibility of detection of $10^{21}$ eV neutrino radio waves.


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