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The Search for Gamma Ray Burst Signatures in Extremely Low Frequency Magnetic Measurements

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On October 9, 2022, a powerful gamma ray burst, GRB221009A, was detected by the Gamma-ray Burst Monitor onboard the Fermi Gamma-ray Space Telescope. Ionizing radiation from GRB221009A generated perturbations of VLF (3 kHz–30 kHz) radio wave propagation on Earth, pointing to significant changes in the electron density of the lower ionosphere [1]. We analyze the lower ELF (0-1000 Hz) frequency band in search for impact of this gamma ray burst on wave propagation in the Earth-ionosphere spherical cavity. We investigate effects on the ELF spectrum observed using an improved magnetic sensor, ELA11, at Hylaty, Poland. The ELA11 sensor has sampling frequency of 3 kHz, a significant improvement in temporal resolution over the previously deployed ELA10 sensor [3]. We focus on the Schumann resonance frequencies or their lowest frequency spectral power-law component. Past work [3,4] indicates that both the phase velocity, v_{ph}, and group velocity, v_{g}, of ELF waves are approximately proportional to the square root of the ratio of the electric altitude, h_E and magnetic altitude, h_M.

$$v_g \approx v_{ph} \approx c\sqrt{\frac{h_E}{h_M}}. \quad (1)$$

where c is the speed of light. The *k*th Schumann resonance frequency responds proportionally to the changes in average phase velocity as approximately

$$f_k \approx 7.5\sqrt{k(k+1)}\left(\frac{\langle v_{ph}\rangle}{c}\right). \quad \text{[Hz]} \quad (2)$$

The time scales taken under consideration are derived from the VLF signal perturbations and range from minutes to seconds. We also studied the received signals' azimuths and the amplitude distribution of the measured magnetic fluctuations. The results do not reveal any clear signature of the gamma ray burst. This suggests that the effect of GRB221009A on the ionosphere may have changed both h_E and h_M values proportionally, thus implying significant ionization over a range of altitudes in the lower ionosphere.

References

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