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Off-axis jet scenario for early afterglow emission of low-luminosity gamma-ray burst GRB 190829A

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Recently, ground-based Imaging Atmospheric Cherenkov Telescopes, such as MAGIC and H.E.S.S., have reported the detection of very-high-energy (VHE) gamma-rays from three gamma-ray bursts (GRB 180720B, 190114C, 190829A). One of them, GRB 190829A, was triggered by the Swift satellite, and about 20000 s after the burst onset the VHE gamma-ray emission was detected by H.E.S.S. with ~ 5 sigma significance. This event had more unusual features than the other VHE gamma-ray events. First, it had much smaller isotropic equivalent gamma-ray energy than typical long gamma-ray bursts and is classified as low luminosity GRB. Second, early X-ray and optical afterglow emission showed a rising part and simultaneously peaked at about 1400 s. We propose an off-axis jet scenario that explains these observational results. In this model, the relativistic beaming effect is responsible for the apparently small isotropic gamma-ray energy and spectral peak energy. Using a jetted afterglow model, we find that the narrow jet, which has the initial Lorentz factor of 350 and the initial jet opening half-angle of 0.015 rad, viewed off-axis can describe the observed achromatic behavior in the X-ray and optical afterglow. Another wide, baryon-loaded jet is necessary for the later-epoch X-ray and radio emissions. Also, we suggest that some of low luminosity GRBs could be explained by off-axis jet scenario.

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