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# Discovery of GeV Gamma-ray Emission from the Galactic Supernova Remnant Kes 41

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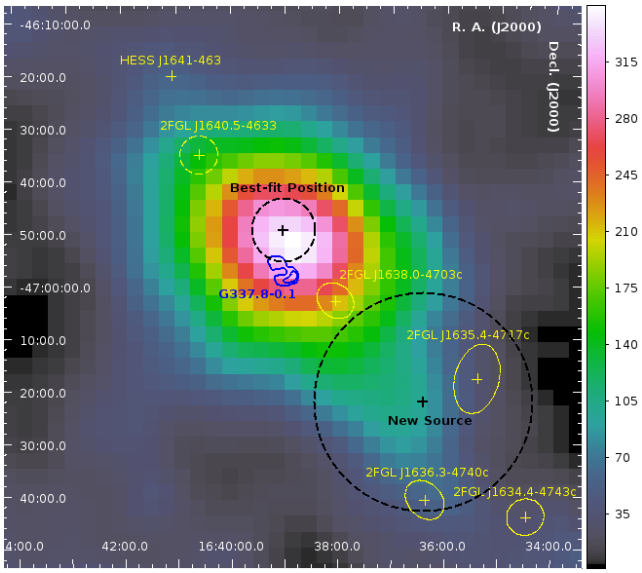
**Özet**

We present the discovery of gamma-ray emission of the mixed-morphology supernova remnant (SNR) G337.8−0.1 (Kes 41) in the energy range of 0.2 − 300 GeV using the data from Large Area Telescope on board of Fermi Gamma-ray Space Telescope (*Fermi*-LAT). SNR shocks interacting with molecular clouds are the best sites to search for the 'hadronic' origin of the gamma-ray emission and the acceleration processes of high-energy particles. There is multi-wavelength evidence for interactions of Kes 41 with a nearby molecular cloud suggesting that it may be a site for cosmic-ray acceleration. In this paper, we present the gamma-ray analysis using the *Fermi*-LAT data of ∼6 years, where we try to disentangle the complex morphology of the neighborhood of Kes 41. We report the detection of Kes 41 at a significance of $\sim 21\sigma$ and a new closeby source ($\sim 31\sigma$), as well as give preliminary results of the extension measurements.

**Anahtar Kelimeler:** (ISM:) supernova remnants, Samanyolu, Galaksiler, Kozmoloji

## 1 Introduction

G337.8−0.1 (Kes 41) is a bright Galactic supernova remnant (SNR) that was reported to have a size of $6' \times 9'$ elongated in the northeast (NE) and southwest direction (SW) by Whiteoak & Green (1996) in the Molonglo Observatory Synthesis Telescope (MOST) catalog (843 MHz). An OH (1720 MHz) maser was detected at a velocity of −45 km s$^{-1}$ (Koralesky et al. 1998; Caswell et al. 2004). Using the CO(1-0) data from the whole-Galaxy survey (Dame et al. 2001), a very massive molecular cloud at a mean velocity of −56 km s$^{-1}$ was found adjacent to Kes 41 (Torres et al. 2003). Analyzing the H I data taken from Southern Galactic Plane Survey, Kothes et al. (2007) reported Kes 41 to be in the Norma II arm (11.5 kpc) of Milky Way at a distance of ∼11 kpc. In X-rays, Kes 41 was detected by XMM-Newton (Combi et al. 2008) and it was classified as a composite or mixed-morphology (MM) SNR (Rho & Petre 1998). XMM data showed no significant pulsations or variability and it's age was reported as ∼16,000 yr. Ergin & Ercan (2012) reported a $\sim 6\sigma$ detection of Kes 41 analyzing the gamma-ray data of ∼4 years of the Large Area Telescope (LAT) on board *Fermi Gamma Ray Space Telescope* (*Fermi*-LAT). Important nearby TeV gamma-ray sources are HESS J1640−465 (Abramowski et al. 2014a; Lemoine-Goumard et al. 2014), and HESS J1641−463 (Abramowski et al. 2014b; Lemoine-Goumard et al. 2014).




**Şekil 1.** Gamma-ray TS map of G337.8−0.1. The black cross and circle are representing the best-fit source locations and their extensions, respectively. Fermi 2nd catalog sources with their positional errors are shown in yellow. The blue contours show the MOST radio continuum data is shown in blue contours (0.375,0.620,0.850 Jy).

## 2 Observation and Analysis

We analyzed *Fermi*-LAT data from 2008 August 4 to 2014 December 12. The events-data were selected from a circular region of interest (ROI) with a radius of 18° centered at the SNR position of $\mathrm{R.A.(J2000)} = 16^{\mathrm{h}}39^{\mathrm{m}}01\overset{\mathrm{s}}{.}0$ and $\mathrm{decl.(J2000)} = -46°59'00\overset{''}{.}0$. Using *gtselect* of Fermi Science Tools (FST), we chose the *Fermi*-LAT Pass 7 events and those events coming from zenith angles smaller than 100°. The maximum likelihood fitting method (Mattox et al. 1996) was employed on the spatially and spectrally binned data using *gtlike* (Abdo et al. 2009) and the P7SOURCE_V6 version of the instrument response function. The background model contains the diffuse background sources (the diffuse Galactic emission, *gal_2yearp7v6_v0.fits*, and the isotropic component, *iso_p7v6source.txt*) and all the point-like sources from the 2nd *Fermi*-LAT source catalog located within a distance of 18° from the ROI center. We fixed all parameters of the sources in the model except the sources that are within the 3° radius of the ROI center, where we set the normalization and spectral parameters free. We added new point-like and extended sources to

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the model (symbols without error circles and symbols with dashed error circles around them in Figure 1). Assuming that Kes 41 is a point-like source, we searched for the best-fit location within the ROI [1]. Then the model was refitted using the best-fit position to compute the TS [2] map shown in Figure 1, where a background model file containing all the point-like sources and diffuse sources and excluding Kes 41 was used. The extension of Kes 41 was tested for a Gaussian type distribution, and we found the best fit location and sigma of the extension to be (l,b) = (337°.9,−0°.001) and 0°.10 ± 0°.08, respectively. The total detection significance of Kes 41 was found to be $\sim 21\sigma$. The extended source model improved the TS over a point-like source by $\sim 8\sigma$. The spectral energy distribution of Kes 41 was considered as a power-law (PL) function which was fit to the data between 0.2 and 300 GeV. The PL fit resulted in spectral index of $\Gamma = 2.30 \pm 0.02$ and the total energy flux was found as $(1.11 \pm 0.10) \times 10^{-10}$ erg cm$^{-2}$ s$^{-1}$ considering that Kes 41 is an extended source.

**Kaynaklar**

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**Erişim**:
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[1] Best-fit location found as $\mathrm{R.A.(J2000)} = 249°.68 \pm 0°.02$ and $\mathrm{decl.(J2000)} = -46°.89 \pm 0°.02$.
[2] TS is the test statistics parameter approximated to the square of the detection significance.