to that of bulk Pt (Fig. 4D). Energy-dispersive spectroscopy (EDS) on the CCM-Pt-6 metal-C nanocomposites (Fig. 4B) showed a composition of 74 wt % Pt, 18 wt % C, 7 wt % O, and 1 wt % S. In contrast, after the plasma treatment, EDS revealed that >98 wt % of the sample was Pt, with only trace contributions from C and O (Fig. 4C). C removal was further confirmed by TGA. Pyrolized samples retained 80% of the original mass when heated to 550°C in air, whereas C-etched samples retained 97% of their original mass. TEM confirmed that the samples were still mesostructured and that the grainy texture indicative of C had disappeared.

Because of the easier accessibility of large quantities, we measured the electrical conductivity only of CCM-Pt-6 Pt-C nanocomposites. We chose two-point measurements, which slightly underestimate the true conductivity, because the pyrolized Pt-C composites were too fragile for a four-point measurement, even when pressed as a pellet (*32*). The NP-polymer hybrid had a conductivity of 2.5 mS/cm, which increased to 400 S/cm upon pyrolysis. Despite the presence of C, to the best of our knowledge this value represents the highest electrical conductivity yet measured for ordered mesoporous materials derived from block copolymers.

Because polymer-NP interactions are largely mediated via the nanoparticle ligands, it may be possible to extend the present approach to other metals for which similarly sized ligand-stabilized NPs can be synthesized. Thus, it may be possible to prepare ordered mesoporous metals of other elements, disordered alloys, or even ordered intermetallics. Furthermore, this discovery also creates a potential pathway to a new class of ordered mesoporous metals made from nanoparticles of distinct compositions. Such nanoheterogeneous mesoporous metals may have a range of exceptional electrical, optical, and catalytic properties.

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Supporting Online Material

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Very-High-Energy Gamma Rays from a Distant Quasar: How Transparent Is the Universe?

The MAGIC Collaboration*

The atmospheric Cherenkov gamma-ray telescope MAGIC, designed for a low-energy threshold, has detected very-high-energy gamma rays from a giant flare of the distant Quasi-Stellar Radio Source (in short: radio quasar) 3C 279, at a distance of more than 5 billion light-years (a redshift of 0.536). No quasar has been observed previously in very-high-energy gamma radiation, and this is also the most distant object detected emitting gamma rays above 50 gigaelectron volts. Because high-energy gamma rays may be stopped by interacting with the diffuse background light in the universe, the observations by MAGIC imply a low amount for such light, consistent with that known from galaxy counts.

Ground-based gamma-ray telescopes are sensitive to the Cherenkov light emitted by the electromagnetic showers that are produced by gamma rays interacting in the atmosphere. These telescopes have discovered, since the first detection (in 1989) of gamma rays in this energy range (from 100 GeV to several TeV), more than 20 blazars, which are thought to be powered by accretion of matter onto supermassive black holes residing in the centers of galaxies, and ejecting relativistic jets at small angles to the line of sight (*1*). Most of these objects are of the BL Lac type, with weak or no optical emission lines. Quasar 3C 279 shows optical emission lines that allow a good redshift determination. Satellite observations with the Energetic Gamma Ray Experiment Telescope (EGRET) aboard the Compton Gamma Ray Observatory (CGRO) had measured gamma rays from 3C 279 (*2*) and other quasars, but only up to energies of a few GeV, the limit of the detector's sensitivity. An upper limit for the flux of very-high-energy (VHE) gamma rays was derived in (*3*).

Using MAGIC, the world's largest single-dish gamma-ray telescope (*4*) on the Canary island of La Palma (2200 m above sea level, 28.4°N, 17.54°W), we detected gamma rays at energies from 80 to >300 GeV, emanating from 3C 279 at a redshift of 0.536, which corresponds to a light-travel time of 5.3 billion years. No object has been seen before in this range of VHE gamma-ray energies at such a distance [the highest redshift previously observed was 0.212 (*5*)], and no quasar has been previously identified in this range of gamma-ray energies.

The detection of 3C 279 is important, because gamma rays at very high energies from distant sources are expected to be strongly attenuated in intergalactic space by the possible interaction with low-energy photons ($\gamma + \gamma \rightarrow e^{+} + e^{-}$). These photons [extragalactic back-

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ground light (EBL) (*6*)] have been radiated by stars and galaxies in the course of cosmic history. Their collective spectrum has evolved over time and is a function of distance. For 3C 279, the range of newly probed EBL wavelengths lies between 0.2 and 0.8 μm (ultraviolet/optical). Existing instruments that are sensitive only to higher gamma-ray energies have so far been unable to probe this domain; by contrast, MAGIC is specifically designed to reach the lowest-energy threshold among ground-based detectors.

In observations of 3C 279 over 10 nights between late January and April 2006 (total of 9.7 hours), the gamma-ray source was clearly detected (at >6 SDs) on the night of 23 February, and may also have been detected the night before (Fig. 1). As determined by the χ^2 test, the probability that the gamma-ray flux on all 10 nights was zero is 2.3×10^{-7}, corresponding to 5.04σ in a Gaussian distribution [see (*7*)]. Simultaneous optical R-band observations, by the Tuorla Observatory Blazar Monitoring Program with the 1.03-m telescope at the Tuorla Observatory, Finland, and by the 35-cm Kungliga Vetenskapsakademien (Royal Swedish Academy of Sciences) telescope on La Palma, revealed that during the MAGIC observations, the gamma-ray source was in a generally high optical state, a factor of 2 above the long-term baseline flux, but with no indication of short time-scale variability at visible wavelengths. The observed VHE spectrum (Fig. 2) can be described by a power law with a differential photon spectral index of $\alpha = 4.1 \pm 0.7_{\mathrm{stat}} \pm 0.2_{\mathrm{syst}}$. The measured integrated flux above 100 GeV on 23 February is $(5.15 \pm 0.82_{\mathrm{stat}} \pm 1.5_{\mathrm{syst}}) \times 10^{-10}$ photons $\mathrm{cm}^{-2}\ \mathrm{s}^{-1}$.

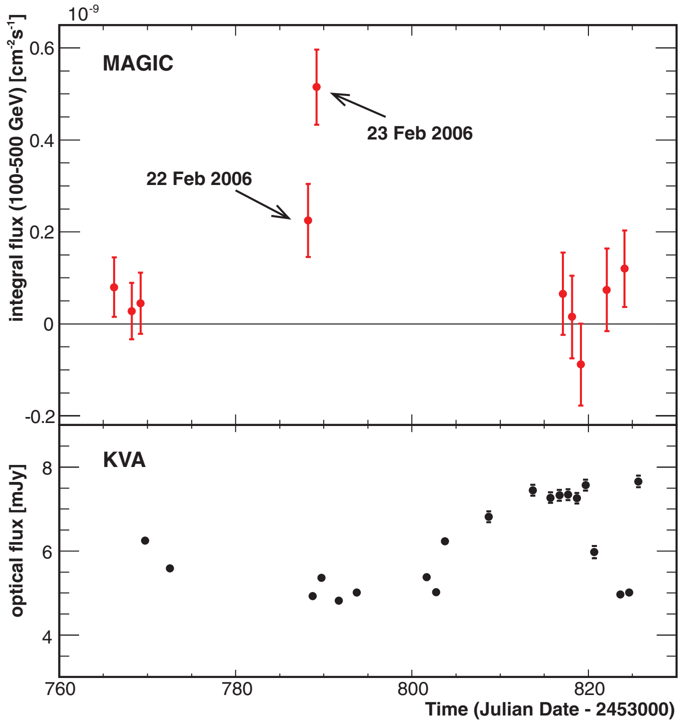

Fig. 1. Light curves. MAGIC (top) and optical R-band data (bottom) obtained for 3C 279 from February to March 2006. The long-term baseline for the optical flux is at 3 mJy.

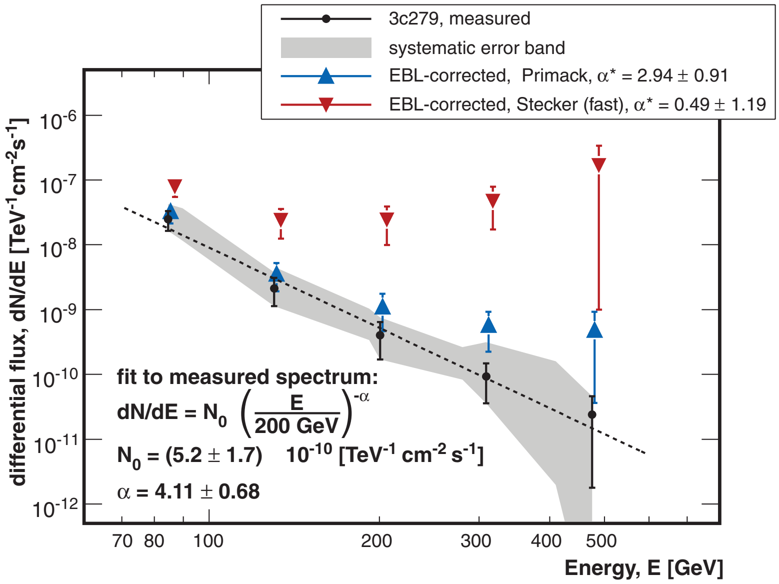

Fig. 2. Spectrum of 3C 279 measured by MAGIC. The gray area includes the combined statistical (1σ) and systematic errors, and underlines the marginal significance of detections at high energy. The dotted line shows compatibility of the measured spectrum with a power law of photon index α = 4.1. The blue and red triangles are measurements corrected on the basis of the two models for EBL density, discussed in the text.

The EBL influences the observed spectrum and flux, resulting in an exponential decrease with energy and a cutoff in the gamma-ray spectrum. Several models have been proposed for the EBL (*6*). All have limited predictive power for the EBL density, particularly as a function of time, because many details of star and galaxy evolution remain uncertain. We illustrate the uncertainty in the EBL by using two extreme models: a model by Primack *et al.* (*8*), close to the lowest possible attenuation consistent with the lower EBL limit from galaxy counts (*9*, *10*); and a "fast-evolution" model by Stecker *et al.* (*11*), corresponding to the highest attenuation of all the models. We refer to these models as "low" and "high," respectively. The measured spectra of 3C 279, corrected for absorption according to these two models, are shown in Fig. 2. They represent the range for the possible intrinsic gamma-ray flux of the source.

A power-law fit to the EBL-corrected points (*12*) results in an intrinsic photon index of $\alpha^* = 2.9 \pm 0.9_{\mathrm{stat}} \pm 0.5_{\mathrm{syst}}$ (low) and $\alpha^* = 0.5 \pm 1.2_{\mathrm{stat}} \pm 0.5_{\mathrm{syst}}$ (high). The systematic error is determined by shifting the absolute energy scale by the estimated energy error of 20% and recalculating the intrinsic spectrum. Further discussion of the intrinsic spectrum and the spectral energy density can be found in (*7*).

The measured spectrum of 3C 279 permits a test of the transparency of the universe to gamma rays. The distance at which the flux of photons of a given energy is attenuated by a factor *e* (i.e., the path corresponding to an optical depth $\tau = 1$) is called the gamma-ray horizon and is commonly expressed as a function of the redshift parameter (*13*); we show this energy/redshift relation in Fig. 3. In the context of Fig. 3, we make use of a model based on (*14*) with parameters adapted to the limits given by (*15*) and fine-tuned such that for 3C 279, the intrinsic photon index is $\alpha^* = 1.5$. The tuning allows for the statistical and systematic errors (1 SD, added linearly). Although the intrinsic spectrum emitted by 3C 279 is unknown, $\alpha^* = 1.5$ is the lowest value given for EGRET sources (not

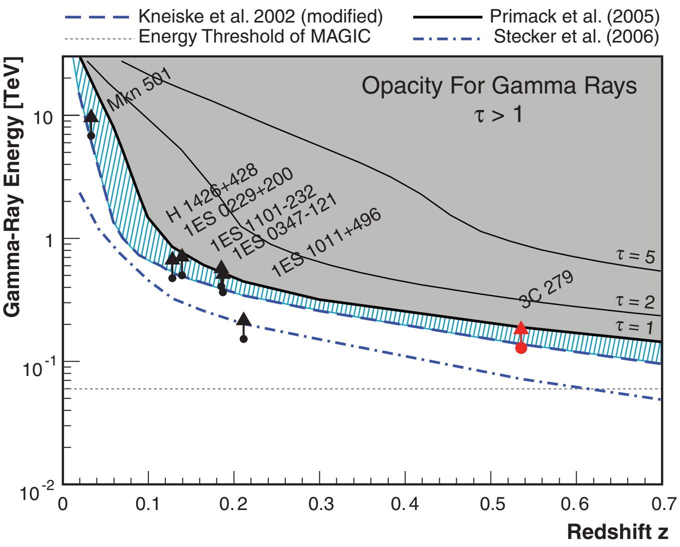

Fig. 3. The gamma-ray horizon. The redshift region over which the gamma-ray horizon can be constrained by observations has been extended up to z = 0.536. The prediction range of EBL models is illustrated by (*8*) (thick solid black line) and (*11*) (dashed-dotted blue line). The tuned model of (*14*) (dashed blue line) represents an upper EBL limit based on our 3C 279 data, obtained on the assumption that the intrinsic photon index is ≥1.5 (red arrow). Limits obtained for other sources are shown by black arrows, most of which lie very close to the model (*14*). The narrow blue band is the region allowed between this model and a maximum possible transparency (i.e., minimum EBL level) given by (*8*), which is nearly coincident with galaxy counts. The gray area indicates an optical depth $\tau > 1$, i.e., the flux of gamma rays is strongly suppressed. To illustrate the strength of the attenuation in this area, we also show energies for $\tau = 2$ and $\tau = 5$ (thin black lines), again with (*8*) as model.

affected by the EBL) and all spectra measured by gamma-ray telescopes so far (*16*), so we assume this to be the hardest acceptable spectrum. The region allowed between the maximum EBL determined by the above procedure and that from galaxy counts (*8*) is very small.

The results support, at higher redshift, the conclusion drawn from earlier measurements (*15*) that the observations of the Hubble Space Telescope and Spitzer correctly estimate most of the light sources in the universe. The derived limits are consistent with the EBL evolution corresponding to a maximum star-formation rate at redshift $z \geq 1$, as suggested by (*8*) and similar models.

The emission mechanism responsible for the observed VHE radiation remains uncertain. Leptonic emission models (assuming relativistic electrons in the jet as the source of the gamma rays), generally successful in describing blazar data [e.g., (*17*)], can, with some assumptions, also accommodate the MAGIC spectrum. Hadronic models [involving relativistic protons, e.g. (*18*)] provide a possible alternative. However, a genuine test of the models can be obtained only with simultaneous observations at different wavelengths, which are not available for the observations described here. Future tests of these models should use observations from sources at all wavelengths from radio to VHE gamma rays. In the domain of VHE gamma rays, we can expect important new insights by simultaneous observations with the Large Area Telescope (LAT), the high-energy gamma-ray instrument on the Gamma Ray Large Area Space Telescope [GLAST (*19*)]. Our observations of this distant source in VHE gamma rays demonstrate that a large fraction of the universe is accessible to VHE astronomy.

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