Астрофизики зафиксировали самый мощный гамма-всплеск во Вселенной

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Article

A very-high-energy component deep in the γ-ray burst afterglow

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Gamma-ray bursts (GRBs) are brief flashes of γ-rays and are considered to be the most energetic explosive phenomena in the Universe[1]. The emission from GRBs comprises a short (typically tens of seconds) and bright prompt emission, followed by a much longer afterglow phase. During the afterglow phase, the shocked outflow—produced by the interaction between the ejected matter and the circumburst medium—slows down, and a gradual decrease in brightness is observed[2]. GRBs typically emit most of their energy via γ-rays with energies in the kiloelectronvolt-to-megaelectronvolt range, but a few photons with energies of tens of gigaelectronvolts have been detected by space-based instruments[3]. However, the origins of such high-energy (above one gigaelectronvolt) photons and the presence of very-high-energy (more than 100 gigaelectronvolts) emission have remained elusive[4]. Here we report observations of very-high-energy emission in the bright GRB 180720B deep in the GRB afterglow—ten hours after the end of the prompt emission phase, when the X-ray flux had already decayed by four orders of magnitude. Two possible explanations exist for the observed radiation: inverse Compton emission and synchrotron emission of ultrarelativistic electrons. Our observations show that the energy fluxes in the X-ray and γ-ray range and their photon indices remain comparable to each other throughout the afterglow. This discovery places distinct constraints on the GRB environment for both emission mechanisms, with the inverse Compton explanation alleviating the particle energy requirements for the emission observed at late times. The late timing of this detection has consequences for the future observations of GRBs at the highest energies.

GRB 180720B

Article

Teraelectronvolt emission from the γ-ray burst GRB 190114C

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MAGIC Collaboration*

Long-duration γ-ray bursts (GRBs) are the most luminous sources of electromagnetic radiation known in the Universe. They arise from outflows of plasma with velocities near the speed of light that are ejected by newly formed neutron stars or black holes (of stellar mass) at cosmological distances[1,2]. Prompt flashes of megaelectronvolt-energy γ-rays are followed by a longer-lasting afterglow emission in a wide range of energies (from radio waves to gigaelectronvolt γ-rays), which originates from synchrotron radiation generated by energetic electrons in the accompanying shock waves[3,4]. Although emission of γ-rays at even higher (teraelectronvolt) energies by other radiation mechanisms has been theoretically predicted[5–8], it has not been previously detected[7,8]. Here we report observations of teraelectronvolt emission from the γ-ray burst GRB 190114C. γ-rays were observed in the energy range 0.2–1 teraelectronvolt from about one minute after the burst (at more than 50 standard deviations in the first 20 minutes), revealing a distinct emission component of the afterglow with power comparable to that of the synchrotron component. The observed similarity in the radiated power and temporal behaviour of the teraelectronvolt and X-ray bands points to processes such as inverse Compton upscattering as the mechanism of the teraelectronvolt emission[9–11]. By contrast, processes such as synchrotron emission by ultrahigh-energy protons[10,12,13] are not favoured because of their low radiative efficiency. These results are anticipated to be a step towards a deeper understanding of the physics of GRBs and relativistic shock waves.

Article

Observation of inverse Compton emission from a long γ-ray burst

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Long-duration γ-ray bursts (GRBs) originate from ultra-relativistic jets launched from the collapsing cores of dying massive stars. They are characterized by an initial phase of bright and highly variable radiation in the kiloelectronvolt-to-megaelectronvolt band, which is probably produced within the jet and lasts from milliseconds to minutes, known as the prompt emission[1,2]. Subsequently, the interaction of the jet with the surrounding medium generates shock waves that are responsible for the afterglow emission, which lasts from days to months and occurs over a broad energy range from the radio to the gigaelectronvolt bands[1–6]. The afterglow emission is generally well explained as synchrotron radiation emitted by electrons accelerated by the external shock[7–9]. Recently, intense long-lasting emission between 0.2 and 1 teraelectronvolts was observed from GRB 190114C[10,11]. Here we report multi-frequency observations of GRB 190114C, and study the evolution in time of the GRB emission across 17 orders of magnitude in energy, from 5×10^{-6} to 10^{12} electronvolts. We find that the broadband spectral energy distribution is double-peaked, with the teraelectronvolt emission constituting a distinct spectral component with power comparable to the synchrotron component. This component is associated with the afterglow and is satisfactorily explained by inverse Compton up-scattering of synchrotron photons by high-energy electrons. We find that the conditions required to account for the observed teraelectronvolt component are typical for GRBs, supporting the possibility that inverse Compton emission is commonly produced in GRBs.

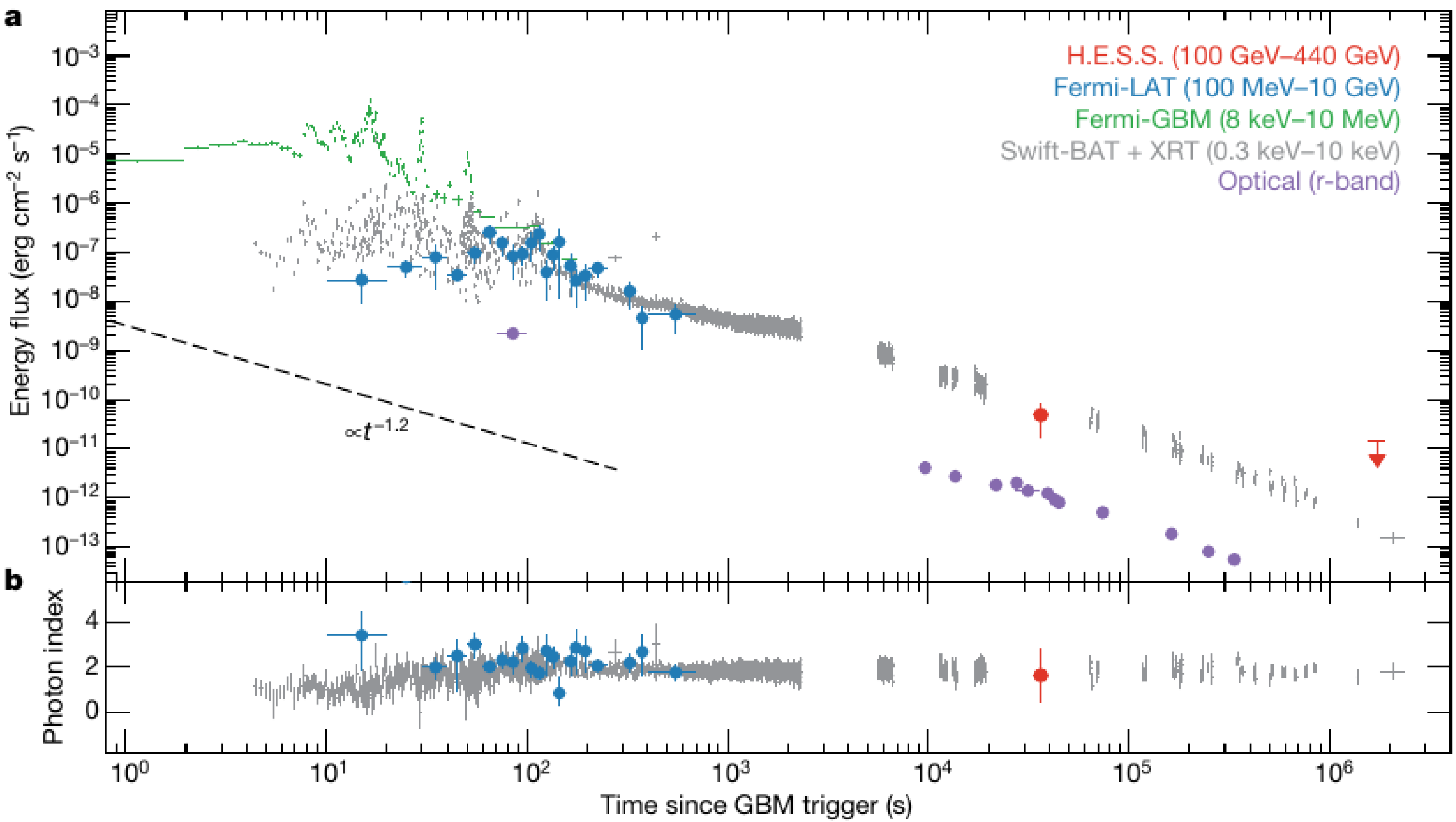

Fig. 1 | Multi-wavelength light curve of GRB 180720B. a, Energy-flux light curve detected by Fermi-GBM (band fit; green), Fermi-LAT (power law; blue), H.E.S.S. (power-law intrinsic; red) and the optical r-band (purple). The Swift-BAT spectra (15 keV–150 keV) are extrapolated to the XRT band (0.3–10 keV) to produce a combined light curve (grey) and an upper limit (95% confidence level) for the second H.E.S.S. observation window (power-law intrinsic, red arrow). The black dashed line indicates a temporal decay with $\alpha = -1.2$. **b**, Photon index of the Fermi-LAT, Swift and H.E.S.S. spectra. Error bars correspond to 1σ.

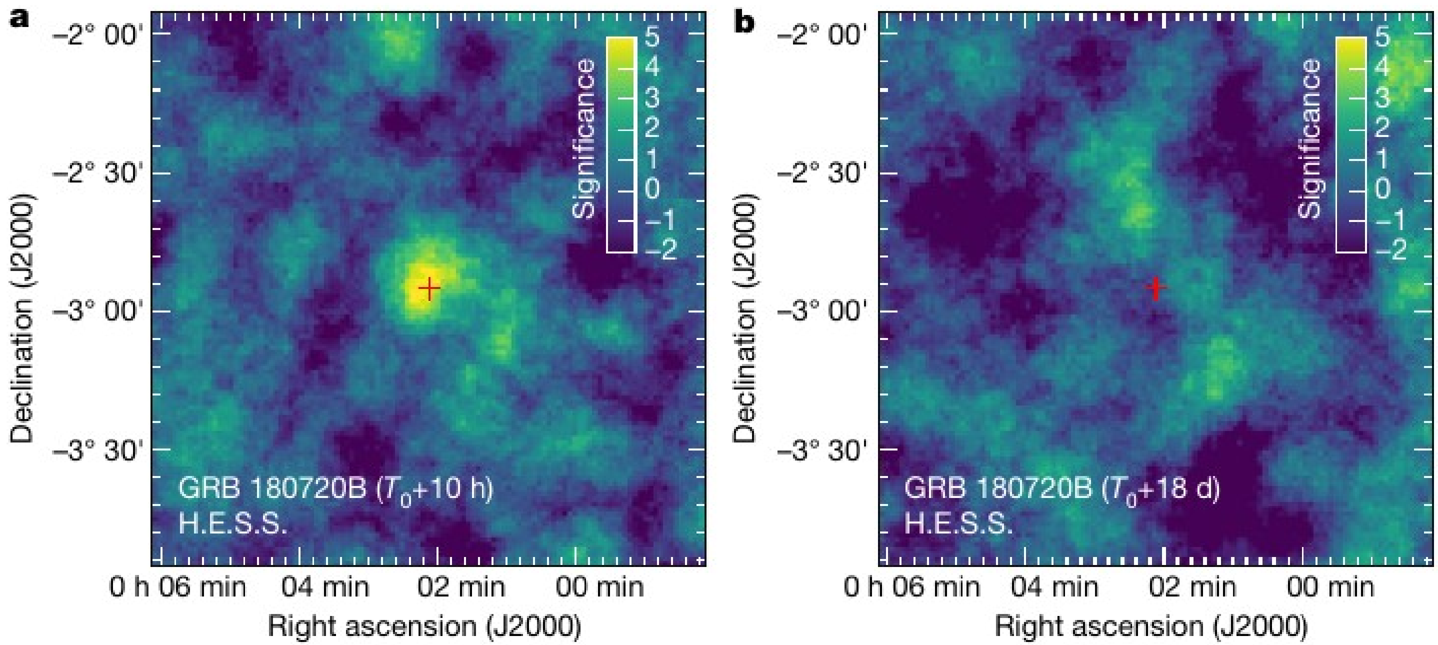

Fig. 2 | Very-high-energy γ-ray image of GRB 180720B. Significance map of GRB 180720B field, as observed by H.E.S.S. **a**, Observation made at T_0 + 10.1 h for 2 h. **b**, The same region of the sky, as observed during consecutive nights between T_0 + 18.4 d and T_0 + 24.4 d. The red cross indicates the position reported by the optical telescope ISON-Castelgrande[12].

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ARTICLES

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Planck evidence for a closed Universe and a possible crisis for cosmology

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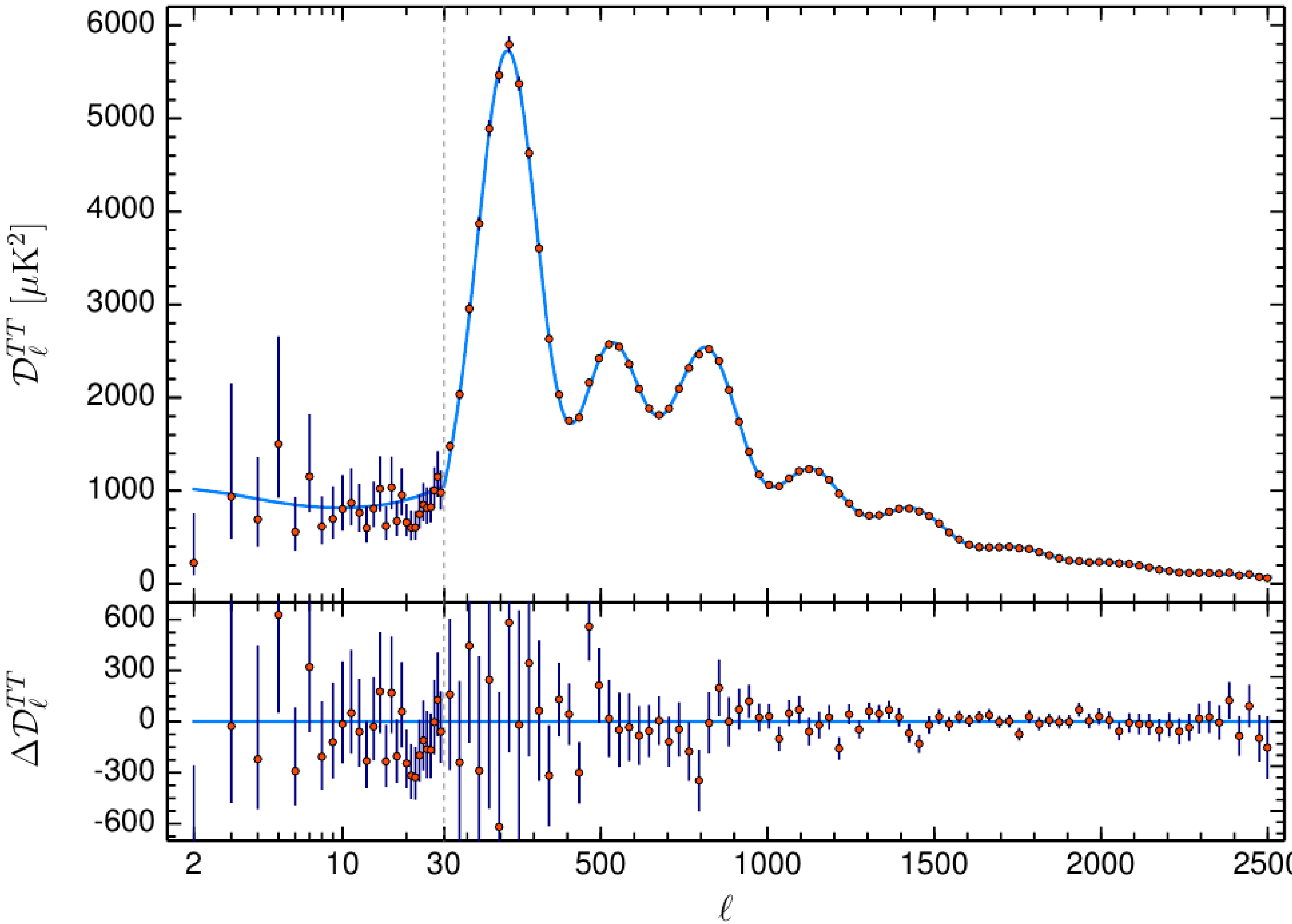
The recent Planck Legacy 2018 release has confirmed the presence of an enhanced lensing amplitude in cosmic microwave background power spectra compared with that predicted in the standard Λ cold dark matter model, where Λ is the cosmological constant. A closed Universe can provide a physical explanation for this effect, with the Planck cosmic microwave background spectra now preferring a positive curvature at more than the 99% confidence level. Here, we further investigate the evidence for a closed Universe from Planck, showing that positive curvature naturally explains the anomalous lensing amplitude, and demonstrating that it also removes a well-known tension in the Planck dataset concerning the values of cosmological parameters derived at different angular scales. We show that since the Planck power spectra prefer a closed Universe, discordances higher than generally estimated arise for most of the local cosmological observables, including baryon acoustic oscillations. The assumption of a flat Universe could therefore mask a cosmological crisis where disparate observed properties of the Universe appear to be mutually inconsistent. Future measurements are needed to clarify whether the observed discordances are due to undetected systematics, or to new physics or simply are a statistical fluctuation.



6000
5000
4000
3000
2000
1000
0
$\mathcal{D}_\ell^{TT}$ [μK^2]
600
300
0
-300
-600
$\Delta\mathcal{D}_\ell^{TT}$
60
30
0
-30
-60
2
10
30
500
1000
1500
2000
2500
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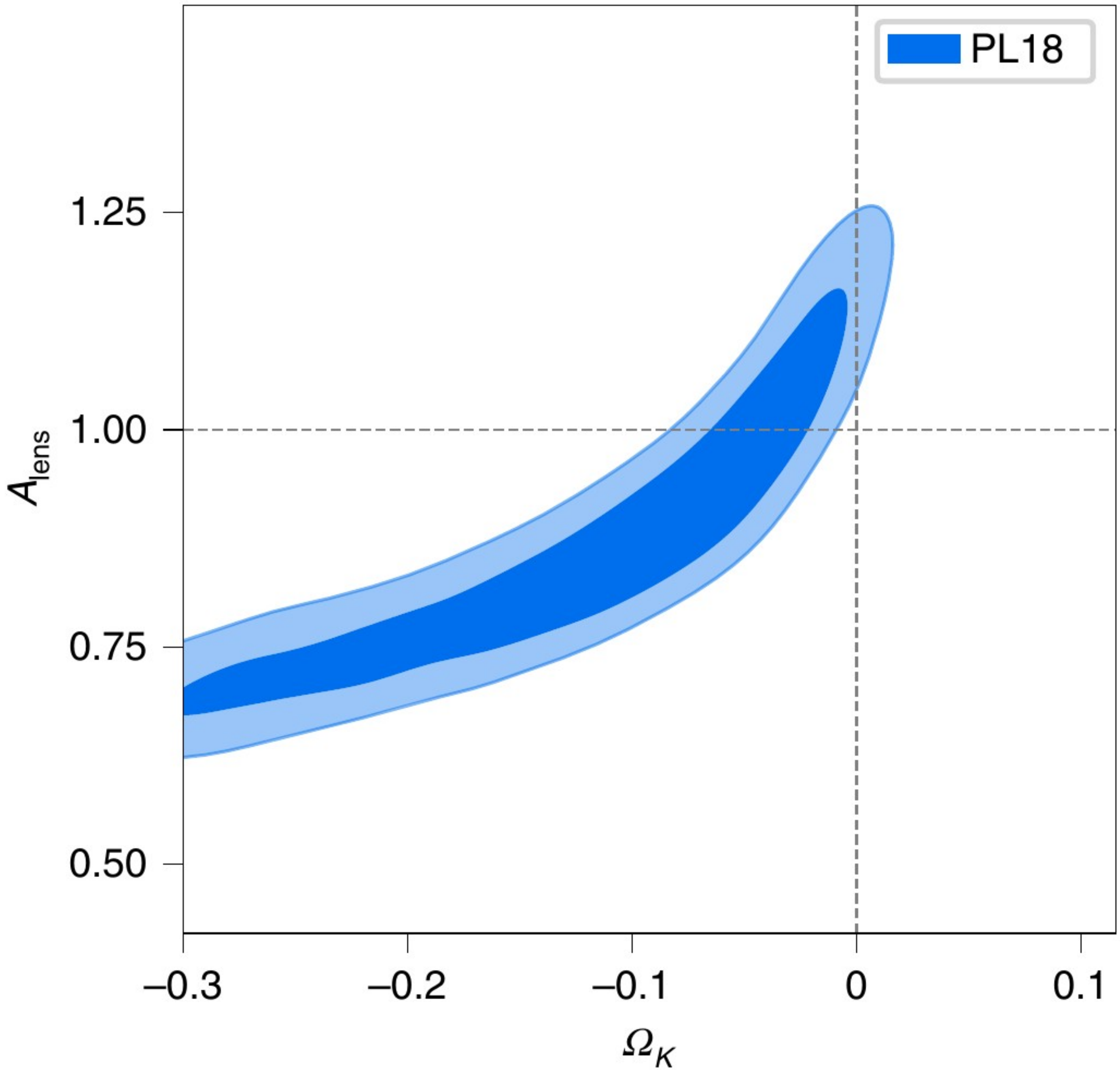
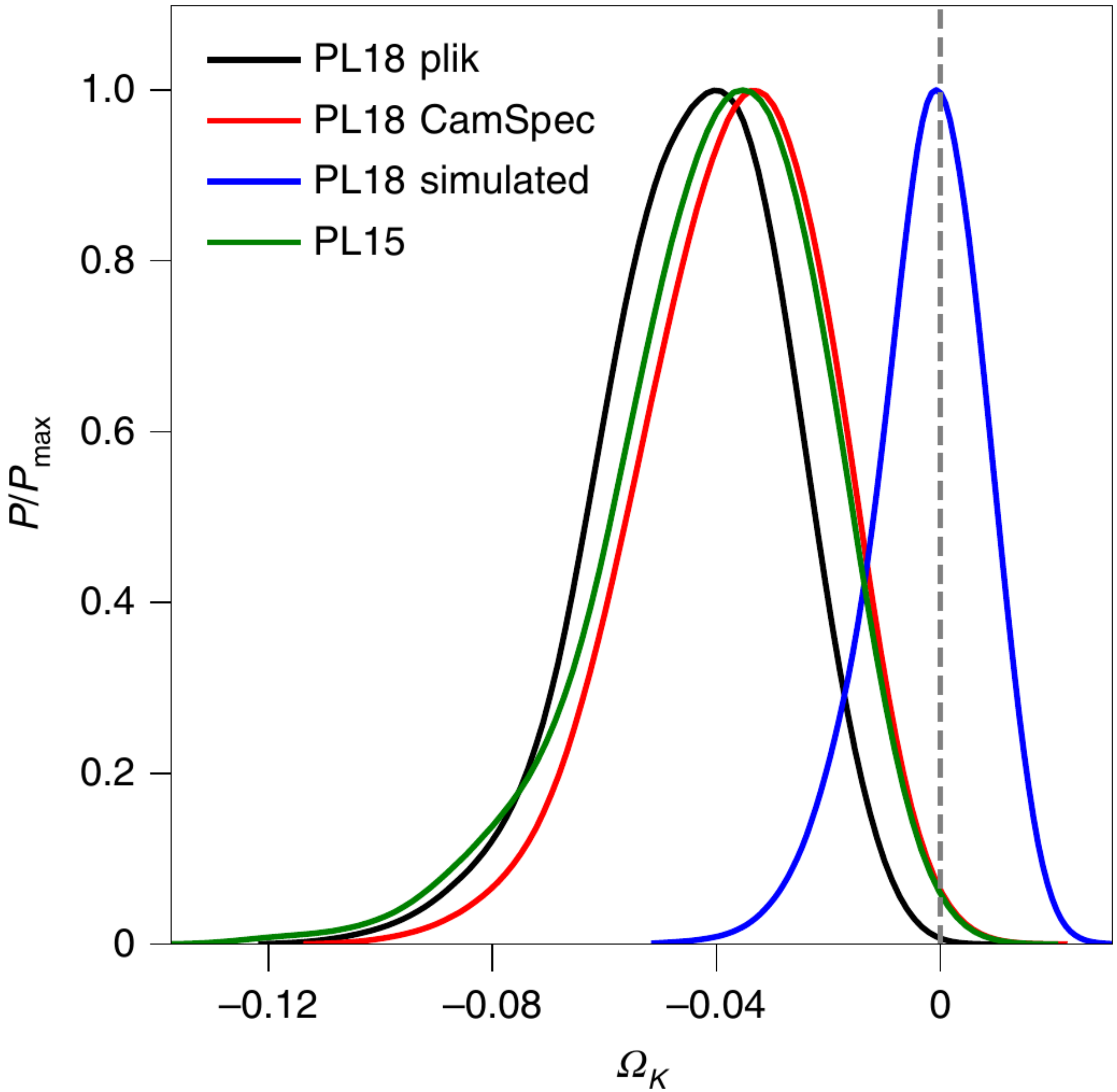

PL18
1.25
1.00
0.75
0.50
A_{lens}
−0.3
−0.2
−0.1
0
0.1
Ω_K

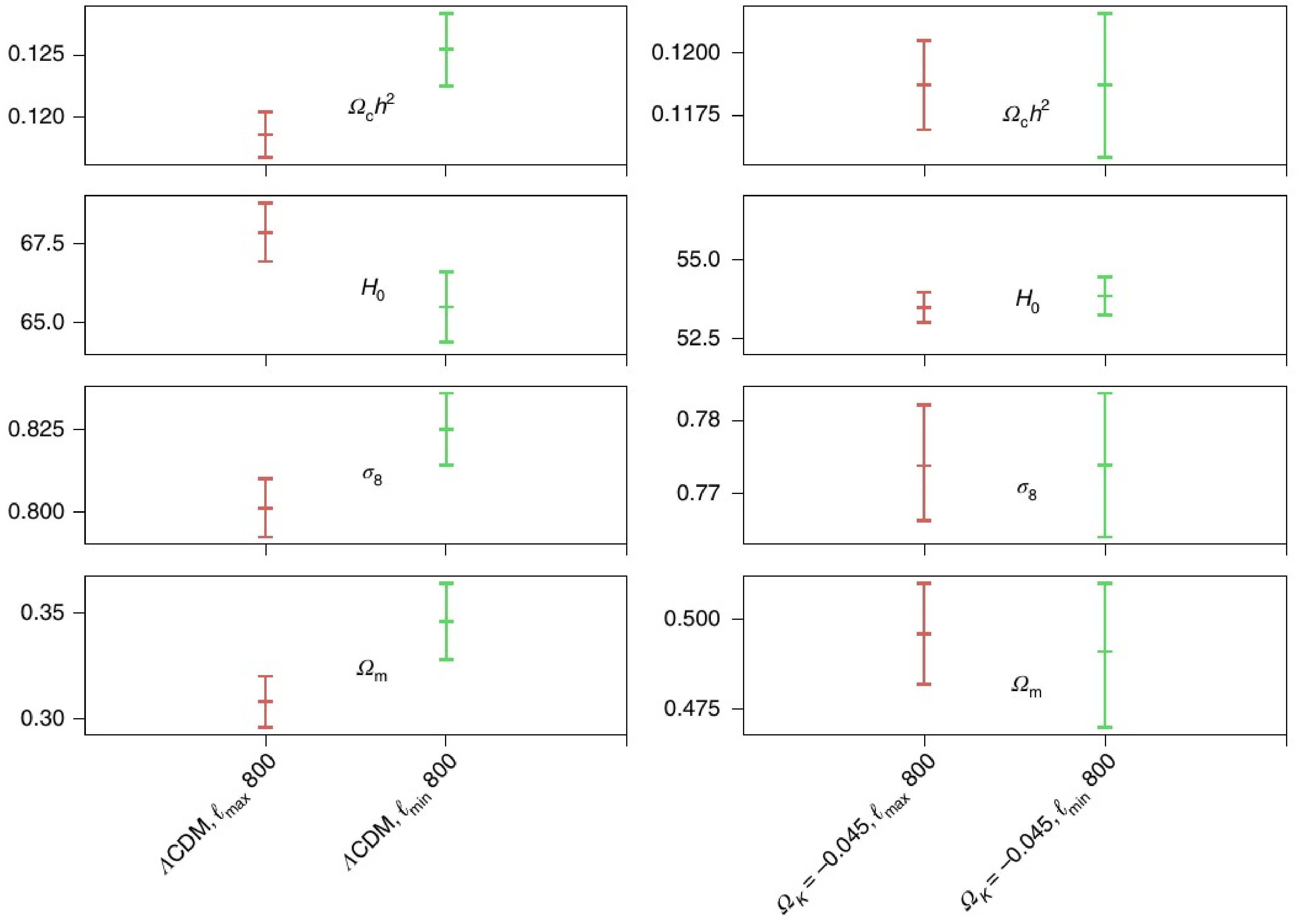


99.985% $\Omega_K < 0$

Best fit:

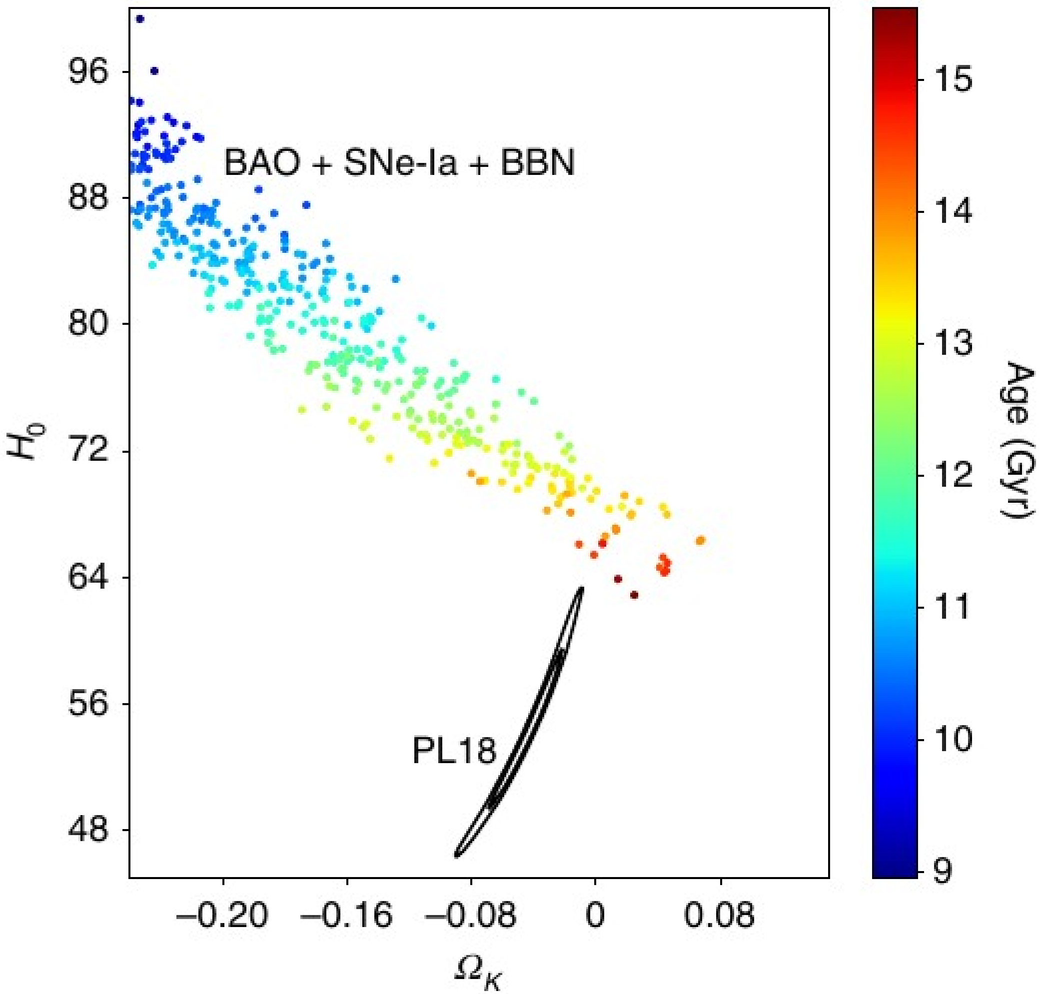
$\Omega_K = -0.0438$

Соответствия космологических параметров по разным угловым мультиполям



Плоская модель

Замкнутая модель



Систематика Planck?

Fig. 7 | Tension with combined data. Contour plots at 68% (inner contour) and 95% (outer contour) CLs from PL18 and 95% CL region from BAO + SNe-Ia + BBN datasets in the H_0 versus Ω_K plane and as a function of the age of the Universe.