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Overcoming the physical limits of Cherenkov telescopes

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Imaging with Cherenkov telescopes was a breakthrough for gamma ray astronomy. However, by pushing Cherenkov telescopes to ever higher precision and ever larger sizes our upcoming generation of telescopes has reached the intrinsic limits of imaging itself. Aberrations limit our field-of-view and the angular resolution in the gamma-ray sky. The square-cube-law escalates the costs to construct rigid structures for the optics of ever larger telescopes. A narrowing depth-of-field in larger telescopes prevents us from lowering the energy threshold for cosmic gamma rays as it blurs the images irrecoverably. While aberrations can be mitigated by more complex and costly optical surfaces, and while the square-cube-law can be mitigated by spending disproportionally more resources, the narrowing depth-of-field is a physical limitation of imaging and the telescope itself which can not be overcome by spending resources. We will show that all these limitations can be overcome by not only measuring the direction of a photon, as the telescope does it, but by additionally measuring the position where the same photon is reflected on the telescope's mirror. With a groundbreaking optics, our proposed Cherenkov plenoscope does exactly this without blocking or losing any light. The plenoscope can tolerate deformations and misalignments of its mirror and camera what postpones the square-cube-law and lowers the costs. The plenoscope can compensate aberrations of its mirror what widens its field-of-view. And the plenoscope turns the telescope's narrow depth-of-field into the perception of this depth giving the plenoscope intrinsic stereoscopic reconstruction power. Plenoptic perception has far reaching consequences for gamma- and cosmic-ray astronomy. We will present one possible consequence which is a Cherenkov plenoscope that aims for an energy threshold of one giga electronvolt for cosmic gamma rays. The plenoscope allows for the first time the high-resolution imaging of low energy gamma ray air showers using a huge (71m) mirror. For the first time we might be able to collect the more abundant low energetic gamma rays, for which the universe is still transparent up to high red shifts, in the large collecting areas of the atmospheric Cherenkov method. With astronomy pivoting towards the time domain, the Cherenkov plenoscope might become the next generation's timing explorer in the gamma ray sky to clock the emission from gravitational mergers, bursts, recurring novas, flaring jets, pulsars, and many more.

Collaboration(s)

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