phase interferometry for direct electric field reconstruction — requires more power and would fail with the double-humped spectrum), the authors instead found a way to take advantage of the well-known characteristics of the two input pulses with well-separated optical spectra.

The measured interferometric autocorrelation function must be reproduced from the sum of the two input pulses by fitting the only three remaining degrees of freedom: the relative intensity ratio, the relative time delay and a relative phase offset. This can be achieved with low uncertainties if special care is taken on the time-delay calibration of the autocorrelation function. Through this method, the authors successfully justify generation of a single-cycle pulse by coherent superposition.

These results should lead to new applications immediately because the laser source demonstrated can be readily used for optical spectroscopy with subcycle time resolution. In the future, with stabilized carrier-envelope offset (which should be easy to accomplish) and ultrabroadband amplification schemes, the laser source could be used as a stable seed for attosecond pulse generation. The working concept also paves the way for other combination approaches, potentially generating few-cycle pulses or even single-cycle pulses in different spectral regions ranging from the visible to the infrared. ❐

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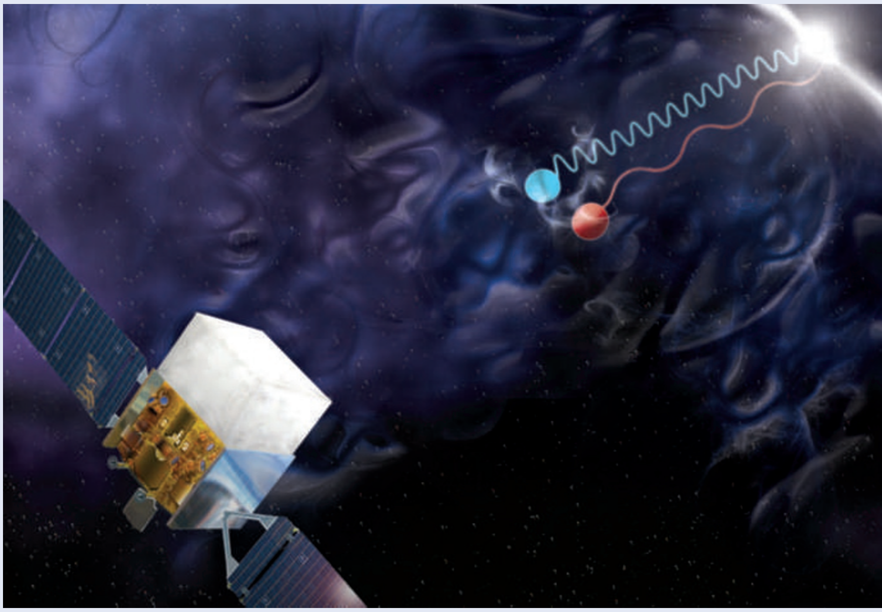
RELATIVITY

Speed of light in the quantum foam



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Einstein's theory of special relativity tells us that the laws of physics are invariant upon Lorentz transformation; that is, they are the same in all inertial frames of reference. This means that any observer, regardless of their speed or direction of motion, should see photons of any wavelength travelling at the same speed through a vacuum.

It has been postulated, however, that the theory may break down at the Planck scale, defined by the Planck length $l_{Planck} \approx 1.6 \times 10^{-33}$ cm and the Planck energy $E_{Planck} \approx 1.2 \times 10^{19}$ GeV. On this tiny scale, where space is sometimes described as quantum foam, quantum effects have been predicted to affect the nature of space–time strongly.

However, an international team of researchers from 63 institutions (*Nature* **462,** 331–334; 2009) has now used photons of ultrashort wavelength to probe the structure of space–time, showing no evidence of Lorentz invariance violation.

To test for tiny differences in speed between photons of different energies, it helps to make observations over travel times of a cosmological scale so that measurable differences can be accumulated. Fortunately, a bright enough source for the job is available — gamma-ray bursts (GRBs). These are the most luminous explosions in the universe; as much energy can be released from a GRB in a few seconds as from the Sun in its entire lifetime. It is thought that GRBs originate from drastic events such as massive stars collapsing into a black hole or when neutron stars coalesce.

On 10 May 2009, the Fermi Gamma-ray Space Telescope detected emission of photons from GRB 090510, with a spread of energies reaching as high as ~31 GeV at a luminous distance of approximately 10^{15} AU.

The team searched this data for time delays between photons of different energy levels. The results indicated that if any variation in speed has occurred, it is within a stringent limit of $1.2E_{Planck}$.

"We used two independent methods, based on the arrival time of the highest energy (31 GeV) photon relative to the lower energy photons, and the lack of smearing of fine time structure (including sharp narrow spikes) that would occur if the speed of light varied with photon energy," explained Jonathan Granot, one of the researchers from the University of Hertfordshire. "GRB 090510 was particularly suitable for testing possible energy dependence of the speed of light because it was short at around one second, had a fine time structure with a sharp spike of ~10–20 ms, and was bright at high photon energies."

Granot told *Nature Photonics* that the measurements strongly disfavour models in which the speed of light varies linearly with photon energy, as this would require their energy or length scale to be significantly beyond that of the Planck scale. "I find it very impressive that more than a century after Einstein came up with his theory of special relativity, it still passes all experimental and observational tests up to the highest available precision."

DAVID PILE

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