cannot be optically excited directly, the authors argue[1] that molecular distortions along the normal mode coordinates of the $H_g$ symmetry phonons could be externally driven (Fig. 1). They suggest that large amplitude vibrations of the infrared active $T_{1u}$ symmetry mode could be induced, resulting in a quasistatic distortion of $H_g$ symmetry through phonon–phonon (anharmonic) interactions[1]. The emanating distortions could enhance electron–phonon coupling strength and/or on-site correlations to promote superconductivity; the lifetime of such a transient superconducting state would be limited by the phonon lifetime to ~1 ps.

Following this approach, intense 300 fs mid-infrared optical pulses at the central frequency $\nu_{\mathrm{MIR}} \approx 43$ THz (180 meV) were used to (resonantly) excite the $T_{1u}$ phonon of the $C_{60}$ molecule. The resulting changes in the electronic properties were recorded by appropriately delayed phase-stable terahertz pulses, providing access to the complex optical conductivity $\sigma(\omega)$ in the frequency range (0.75–2.5 THz) relevant to the superconductivity fingerprints of $K_3C_{60}$ (in equilibrium $2\Delta/h \approx 1.5$ THz for $T << T_c$). Indeed, for base temperatures far above $T_c$, the $\sigma(\omega)$ recorded at time 1 ps after optical excitation displays features that are consistent with photoinduced superconductivity: a gap in the real part of conductivity, $\sigma_1(\omega)$, and an enhancement of the imaginary part of conductivity, $\sigma_2(\omega)$, indicative of the inductive response of the condensate. Similarly, the theoretical estimates of the driven quasistatic distortions and their effect on electron–phonon coupling strength and electronic correlations[1] seem to support this idea.

If the results are indeed consistent with the light-induced superconductivity driven by distortions of $C_{60}$ molecules, what are the reasons for the word ‘possible’ used in the title of the manuscript[1]? Principally, terahertz pulses can neither provide evidence of infinite conductivity at zero frequency, nor can the expulsion of the magnetic field (another hallmark of superconductivity) be determined within the 1 ps time window. But this is an academic argument.

More nontrivial is the fact that experiments performed at temperatures below $T_c$ show a photoinduced suppression of superconductivity. Note that $2\Delta$, deduced from $\sigma_1(\omega)$ in the photoinduced state at 25 K, is twice the size of the superconducting gap in equilibrium. Following the presented line of thought, where amplification of superconductivity is a result of an increase in pairing strength, one would expect massive gap enhancement also at low temperatures.

Finally, as pointed out by the authors[1], there are several alternative interpretations that could account for the observed $\sigma(\omega)$ in the photoinduced state; for example, a photoinduced sliding charge density wave seems viable. Indeed, taking $K^+$-ion optical phonons as being responsible for the pairing of carriers in $C_{60}$ molecules, it was shown[9] that a charge density wave state may be stabilized in $K_3C_{60}$. In a highly non-equilibrium state as here, such a scenario seems equally plausible.

Clearly further experiments and theoretical modelling are required to determine the nature of the observed transient state. Regardless, the presented results are striking, presenting fascinating emergent phenomena far away from equilibrium. ❐

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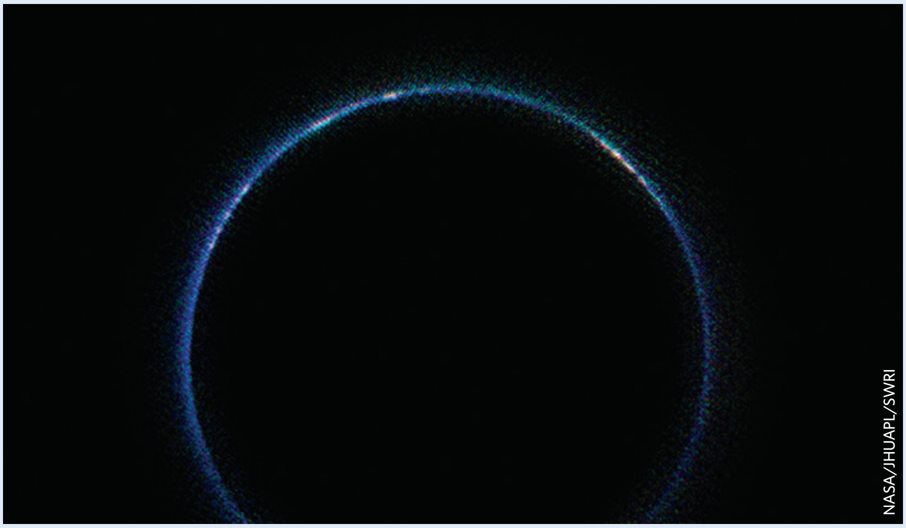
NEW HORIZONS

# Small but still special

Pluto may be a planet no longer, but it still has an atmosphere (unlike Mercury). This image, taken by infrared cameras aboard the New Horizons spacecraft on 14 July 2015, shows Pluto’s atmosphere at a distance of 180,000 km. It is a true-colour image captured while Pluto was backlit by the Sun, with New Horizons in its shadow (known as occultation). The blue colour comes from sunlight scattering off particles in the haze — a smog consisting of mostly nitrogen gas and particles of mixed hydrocarbons such as acetylene and ethylene.



NASA/JHUAPL/SWRI

Given Pluto’s distance from Earth, 7.5 billion km at its greatest, the atmosphere was not detected, even indirectly, until 1976. Its surface is mainly nitrogen ice, with frozen methane and carbon monoxide. Incoming cosmic rays vaporize the surface ices to replenish the atmosphere. As the gravity (0.66 m s$^{-2}$) and atmospheric pressure (1 Pa) are weak, the gases escape at a rate of $10^{27}$–$10^{28}$ molecules of nitrogen per second, or at least several hundred metres of surface material over the lifetime of the Solar System. New Horizons will be able to quantify the surface loss so we can gain a better understanding of Pluto’s surface evolution.

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