film on graphene/Ru(0001) showed a small magnetic contrast, which reveals the long-range ferromagnetic order.

However, the nature of the magnetism in TCNQ/graphene/Ru(0001) is far from fully understood. Calculations using a constrained model and a reduced system size containing just the main physics components gave some insight into the electronic structure of the adsorbed TCNQ molecules and explained the physical reason for the stability of the magnetic order. Nevertheless, important information — for example the temperature dependence, local electronic interactions and the band dispersion of states close to the chemical potential — still needs to be uncovered by future experiments. In particular, the 'exchange' mechanism that ferromagnetically couples the local moments to each other is rather complex, because it includes the properties of the molecules, the graphene layer and the ruthenium substrate.

The results described by Garnica and co-workers point to a new direction in the growing field of organic electronics and graphene-based devices. Although most approaches — some close to realization — rely on classical magnetic elements, this research shows that there are alternative routes in organic electronics or spintronics. Devices such as spin-filters or 2D spin polarizers require that hetero-systems are designed, to combine the unique properties of graphene with magnetism. The work by Garnica *et al.* indicates that this can be obtained even by the combination of organic molecules consisting merely of carbon, nitrogen and hydrogen. ❐

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MATERIALS SCIENCE

Crack scene investigation

A star break in your windscreen is perhaps more likely to cause concern about its repair than interest in how it came to have its 'starry' shape. However, in work that is relevant to such diverse fields as forensic science, archaeology and astrophysics, Nicolas Vandenberghe and colleagues show how much these cracks reveal about the impact that caused them, and about the windscreen's material properties (*Phys. Rev. Lett.* **110,** 174302; 2013).

Vandenberghe *et al.* fired bullets from a gas gun at plates made from polymethyl methacrylate (PMMA) or soda-lime glass, between 0.15 and 3.0 mm thick. The 'bullets' were in fact steel cylinders, with hemispherical heads of radii 1.8 mm and 0.5 mm for the PMMA and glass plates, respectively. Aimed perpendicularly at a plate, the projectiles hit at speeds ranging from 10 to 120 m s^{-1}. A high-speed camera, placed behind the target, recorded the evolution of each plate's deformation.

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The team noted many different patterns featuring radial cracks. In general, for PMMA plates, and bullet speed above some minimal limit, the number of crack lines grows with increasing impact velocity. For a 1-mm-thick plate, as bullet speeds vary from 15 to 120 m s^{-1}, the number of spokes in a crack increases from 3 to 11. Above 120 m s^{-1}, the sectors — or 'petals' — bounded by radial cracks break first near the impact spot, resulting in a pattern of circumferential fractures — a kind of spider-web of cracks. At still higher speeds, many small PMMA fragments are ejected from the crash zone, leaving a circular opening — nothing but a bullet hole. From a 'material' point of view, the highest speeds are the least damaging.

For glass targets, pulling the trigger creates similar crack patterns. Combining the results from all the shots, Vandenberghe *et al.* have derived an approximate master curve that captures the growing number of radial cracks with increasing impact speed. Other material parameters— such as the fracture energy, Young's modulus, Poisson ratio and density— are also taken into account. A physical explanation for the scaling law, as seen in these experiments, follows from minimizing the system's total energy: the sum of bending and fracture energy.

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