graphene epitaxially onto Cu(111) (ref. 8) in such a way that all of the copper atoms just below the graphene are in registry with the carbon atoms. However, as there are fewer copper atoms than carbon atoms, some carbon atoms have no copper atoms below them. It is these vacancies that play the role of the adatoms in the scenario described in refs 5 and 6. Gutiérrez *et al.*[1] call these vacancies ghost adatoms and their ordering is called ghost Kekulé order. Such order opens a bandgap at the Dirac point, and imparts a mass on the Dirac fermions.

From the point of view of effective field theories, the dynamical generation of a fermionic mass through the spontaneous symmetry breaking of an emergent chiral U(1) × U(1) symmetry down to its unbroken U(1) electromagnetic charge symmetry group is the same mechanism as that advocated in a seminal paper by Nambu and Jona-Lasinio in 1961[9] to explain the origin of the nucleon masses.

Unlike the Haldane mass that supports edge states along lines at which the corresponding order parameters vanish, the Dirac masses that encode the Kekulé ordering come in pairs. As such they support vortex-like defects that bind zero modes[4]. This phenomenon is accompanied with a fractionalization of quantum numbers, say a fractional charge if the electronic spin is polarized[4]. There should be points in the STM field of view where three distinct Kekulé domains meet, thereby creating vortex-like defects, and so it should be possible to experimentally probe the associated localized states with fractional quantum numbers.

A final caveat to note is that copper is metallic, so it shorts any transport (or lack thereof) in the graphene, which means that this is perhaps not the perfect system for device applications. But this is certainly a promising first step towards endowing graphene with transport properties that can be tuned from the semimetallic to the insulating regimes. ❐

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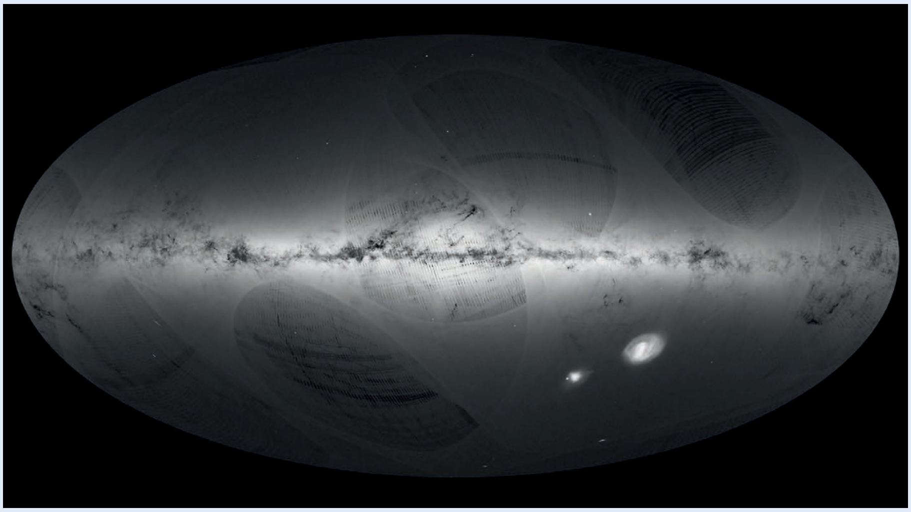
GALACTIC ASTRONOMY

A billion stars in our grasp

On 14 September, the team behind the European Space Agency satellite Gaia released their first data set, spanning almost one year of observations. After imaging more than one billion stars, Gaia focused on the brightest two million objects, obtaining both their distance and motion in three dimensions. The all-sky map (pictured) shows that the Milky Way running across the centre of the image is larger than we thought, as are the Large and Small Magellanic Clouds — two dwarf galaxies appearing as bright spots in the lower-right region of the map. (The stripes are a measurement artefact that will disappear with more data.)

The reason for the increased sizes is Gaia's incredible sensitivity. Its billion-pixel CCD camera, orbiting 1.5 million kilometres from Earth, can measure the properties of stars that are a million (10^6) times fainter than the unaided human eye can observe. This is 10,000 times more stars and down to an impressive 1,000 times fainter objects than its predecessor, the Hipparcos mission.

Over five years of operations, Gaia will observe each of the one billion objects (about 1% of the Milky Way) on average seventy times. This kind of sampling will allow astronomers to measure the celestial motion of stars and quantify their brightness variations. The combination of astrometry, photometry and spectroscopy provided by Gaia will be used to map in detail the baryons and dark matter distribution in our Galaxy; to refine distance measurements as far as the Magellanic Clouds, based on observations of 'standard candles' such as Cepheid stars; and to accurately determine the initial mass distribution of young stars in star-forming regions in our Galaxy.



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The first data release boasts sub-milliarcsecond resolution in stellar positions and a sensitivity limit matching the pre-launch expectations. So far, Gaia has measured nearly 4,000 variable stars (12% of them previously unknown to be variable) and 400 star clusters, and resolved dark clouds in Orion, which were unknown before. It will also be able to image tens of thousands of exoplanets (Jupiter-type). These are impressive feats, considering Gaia has suffered a series of unexpected technical setbacks — these include excess water freezing on the optics of the telescope and stray light from the sunshield protecting the satellite — and is a testimony to the work of 450 people from 24 countries contributing to the Gaia consortium.

MARIOS KAROUZOS