form of the moulting fluid, and protein analysis suggests that it has high nutritional value, although its exact function needs to be clarified. In other insects, moulting fluid is instead reabsorbed by the pupa itself and recycled for the insect's own use. However, Snir and colleagues reveal that, for ants, the fluid provides shared nutrition, and is distributed to other group members to optimize colony growth, particularly larval development.

The authors report that this fluid enhances colony fitness as assessed by examination of larval growth. But the secretion, like mammalian milk, is costly for the secretor. If the ant fluid is not collected quickly by nest-mate workers, the pupa can become susceptible to fungal infection and die.

A contribution of juveniles to their society is known for many species, including juvenile birds and the sterile workers of naked mole rats[3]. The latter is a representative of what are called eusocial animals. Eusociality (a word with a root that includes the Greek *eu*, meaning good) is characterized by division of labour between reproductive individuals and non-reproductive workers that care for the young; high levels of cooperation; and low levels of conflict among members of the same social unit. The almost 15,000 known species of ant are all eusocial, and ants have evolved one of the most advanced forms of insect social organization and cooperation.

Ant juveniles' contributions to societal requirements have been identified previously. For instance, the larvae of some species secrete silk, which is used to build the nest[4], and eggs and larvae spread the queen's pheromone molecules to colony members[5]. However, pupae, motionless and often enclosed in their cocoon, have been considered comparatively useless. Snir and colleagues' research shatters this assumption and greatly advances our knowledge about the role of the brood (non-adult ants) in ant social dynamics.

It is surprising that, in the history of modern ant science, a century after pioneering studies of ant social behaviour by William Morton Wheeler, ant researchers have observed these societies and yet failed to notice the existence of the phenomenon reported by Snir and colleagues. Wheeler and other scientists of that era focused on mouth-to-mouth or anus-to-mouth nutrition sharing, which is common in, but not restricted to, social insects, and which was termed trophallaxis in 1918 by Wheeler himself[6] (from the Greek *tropho-* and *-allaxis*, meaning exchange of nourishment). Wheeler and his contemporaries thought that the interdependence of nutrition between group members is key to understanding the evolution of social life, and that nutrition circulates through an insect society just as blood circulates in the body and money moves around human societies.

This nutrition theory fell out of favour in the late twentieth century, when explanations of social evolution in ants and other social insects, as provided through the lens of population genetics, grabbed the limelight[7]. However, the nutrition theory is regaining prominence this century, because it might offer a complementary explanation[8]. Advances in modern technologies, such as protein analysis, are helping to clarify the mechanistic function of complex behaviours. We now know that, during trophallaxis, ants exchange not only nutrients, but also a variety of bioactive substances that are related, for instance, to caste differentiation (such as whether an ant becomes a queen or a worker), immune defence and maintenance of gut microorganisms[9]. Trophallaxis also has a key role in the recognition of group identity through the homogenization of colony odour[10].

Snir *et al*. demonstrate that the pupal fluid secreted by motionless pupae of five species, belonging to the five major ant subfamilies, has a social function. When this role evolved is not known. The authors found that honeybees, another highly social lineage, do not show this behaviour. Pupae in honeybee and wasp societies are typically enclosed in individual hard cells, whereas ant pupae are kept in brood piles that are moved around the nest by the workers. This might be a crucial difference, suggesting an idiosyncratic role for the nutritional pupal fluid in the evolutionary trajectory of ant societies, and highlighting the importance of shared nutrition in social evolution. Just as nutrients circulate in ant societies, ideas about the evolution of insect societies can come full circle.

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Astronomy

Loops bring news from the Galactic black hole

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Analysis of radio emission from matter near the Milky Way's central black hole sheds light on this previously unobservable region, revealing that the local magnetic field is carried around in complete loops by the matter orbiting the centre.

The Milky Way, like most galaxies, harbours a supermassive black hole at its centre: the formidable Sagittarius A*, which has a mass that is four million times that of the Sun. The activity of central black holes depends on the rate at which they accrete material to fuel them. When this matter approaches the event horizon, the boundary beyond which it can no longer escape the black hole's gravitational pull, the characteristics of the inwards migration can reveal certain properties of the black hole, such as the rate and orientation of its spin. Writing in *Astronomy & Astrophysics*, Wielgus *et al*.[1] report an analysis of emission from Sagittarius A* that they interpret as the signature of a 'hot spot' orbiting the black hole at a radius only five times that of its event horizon — offering the potential for probing the innermost region of the accretion flow.

The matter accreted by Sagittarius A* comes mostly from stellar winds, which are produced by young massive stars in close orbit around the black hole[2–4]. However, less than one-thousandth of the material that these winds feed into the accretion flow actually reaches the event horizon. The rest gets ejected by the tremendous amount of thermal, kinetic and magnetic energy that is generated as matter accelerates towards the black hole, and this surviving material can be observed at radio, infrared and X-ray wavelengths. Wielgus *et al.* studied millimetre-wavelength radio emission from Sagittarius A*, observed using the Atacama Large Millimeter/submillimeter Array telescope (ALMA) in northern Chile.

As the material approaches the event horizon, it has so much energy that many of its particles move at relativistic speeds (close to the speed of light). When these relativistic particles interact with the magnetic field that is generated by the accretion flow, they induce radiation called synchrotron emission, and this is precisely what the authors observed. Synchrotron emission is intrinsically polarized, meaning that its waves tend to oscillate in a specific direction, and this direction is perpendicular to that of the local magnetic field. This type of emission therefore offers a way of studying the geometry of this magnetic field.

Emission from Sagittarius A* varies rapidly on timescales of minutes to hours[5], and frequently exhibits flares (peaks in activity), during which the brightness can increase a hundredfold. Such flares are visible at infrared and often at X-ray wavelengths, but are less pronounced at radio wavelengths[6–8], and the physics behind this wavelength-dependent activity is not well understood. The flares have been attributed to various mechanisms, including instabilities in the accreting fluid flow — and also to a process known as magnetic reconnection, which can lead to a sudden release of energy that produces a local hot spot in the accreting material[9]. Alternatively, the chaos created by colliding stellar winds can generate clumps of gas in the accretion flow, and when these clumps are sufficiently heated, they can turn into local hot spots, in which particles become relativistic and emit synchrotron radiation.

The first images of the immediate vicinity of Sagittarius A* were reported this year in the 1.3-millimetre frequency band by the Event Horizon Telescope (EHT) collaboration, offering a close-up view of the glowing gas soon to be swallowed by the black hole[8]. This collaboration coordinates observatories around the world, and ALMA is one of the key players in this phenomenal effort. Wielgus *et al.* analysed the ALMA part of the EHT observations of Sagittarius A*, focusing on data obtained immediately after a bright X-ray flare that was observed on 11 April 2017 by NASA's Chandra telescope[10].

The authors found that, in the aftermath of this flare, the direction of the polarization vector changed continuously, making complete loops on a timescale of around an hour (Fig. 1). These loops were not evident in data collected before the X-ray flare. The natural interpretation is that the magnetic field at the source of the emission followed the orbital path of the emitting gas, and rotated through a complete cycle. This is consistent with the orbital motion of hot spots around Sagittarius A*, which were detected in high-resolution infrared observations made in 2018 by the GRAVITY instrument on the European Southern Observatory's Very Large Telescope[11].

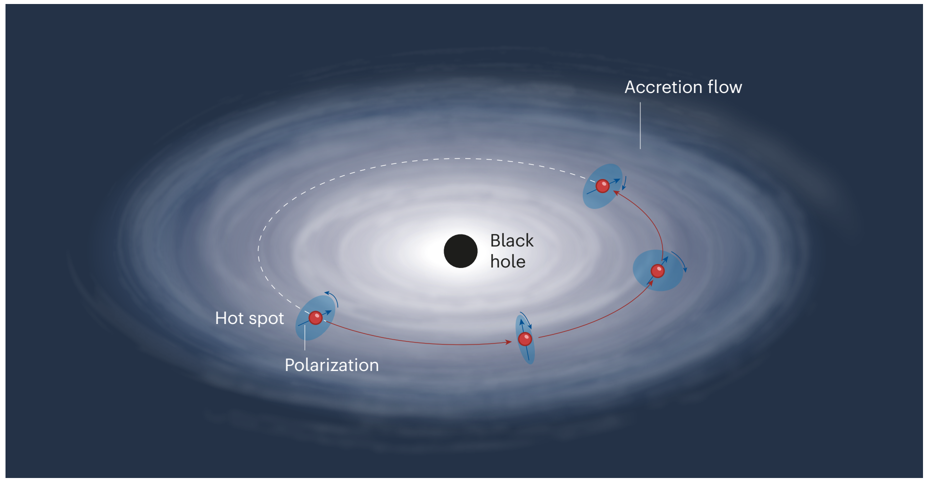

Figure 1 | A hot spot orbiting a supermassive black hole. Sagittarius A* is the supermassive black hole at the centre of the Milky Way. It accretes gas that orbits around it, and this hot gas emits fluctuating radiation at radio, infrared and X-ray wavelengths, sometimes in the form of bright 'flares'. Wielgus *et al.*[1] analysed radio emission from one of these flares, specifically the direction in which the emission is polarized, which is perpendicular to the direction of the local magnetic field. They found that the polarization direction looped around the black hole in the aftermath of the flare, which suggests that the local magnetic field followed the orbit of the emitting gas as it spiralled towards the black hole. This is consistent with a previous detection[11] of 'hot spots' orbiting Sagittarius A*, which could be similar to the source of the emission analysed by Wielgus and colleagues.

ALMA does not have high enough spatial resolution to detect individual hot spots or clumps moving in the accretion flow. However, Wielgus *et al.* used a simple model of a black hole and its accretion flow to estimate which physical parameters (such as the direction in which the flow rotates, and the orientation of the magnetic field) could reproduce their observations, and came up with parameters similar to those obtained using the GRAVITY data. It is therefore tempting to interpret the ALMA and GRAVITY results as different signatures of the same phenomenon.

Wielgus and colleagues' study opens the door to a way of observing phenomena near a black hole's event horizon in real time. However, the hot-spot scenario needs to be confirmed. A blob of hot gas so close to the black hole would be subjected to tremendous shear forces under the influence of the black hole's tidal (gravitational) force, and it isn't clear how long such a blob would remain intact. The behaviour observed by the authors might also be interpreted as the result of spiral waves in the accretion flow. In this scenario, the synchrotron radiation would not be emitted by the same material as it loops around the black hole. Interpretation of the observations is complicated by the fact that emission from material near an event horizon can also be affected by a phenomenon called gravitational lensing, which occurs when a large gravitational field bends and magnifies emitted light.

Many more of these events will need to be tracked and characterized to significantly constrain the nature of the emission source, as well as the associated physical parameters, such as the rate at which the black hole spins. This will require perseverance, because Sagittarius A* produces bright flares only about once per day[5]. Fresh perspectives on black-hole phenomena, such as that reported by Wielgus and colleagues, are invaluable, especially if coupled with coordinated observing campaigns between ALMA, GRAVITY and Chandra. Having these instruments operating simultaneously, at the right time, is a challenge and requires considerable serendipity, but it is worth the effort to elucidate the phenomena occurring in the innermost region around supermassive black holes.

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