pressure difference across the metal's surface strong enough to pull reactants across, allowing electron donation to happen and the desired chemical reaction to occur. The deformation of the droplet as it tenses and relaxes within its cavity pumps the resultant chemical away, allowing fresh reactants to flow in and the process to begin again. The researchers successfully applied this model to three different reactions, including the reduction of flakes of graphene oxide, which is useful for purifying water and in energy storage.

And this is only the latest in a growing body of experiments and prototyping aimed at exploiting the unique properties of liquid metals. In 2014, Dr Kalantar-Zadeh's group developed a pump capable of driving liquids around a circuit by similar means, but which did not exploit the metal's reactivity. In 2016, miniature robots were fitted with liquid metal wheels that could be steered across an aqueous solution by manipulating their surface tension. In 2018, wheels containing droplets of liquid metal were developed that changed their centres of gravity in the presence of electric fields, thereby causing the wheels to rotate. In 2021, another group of researchers devised a liquid metal-powered motor that suffered far less wear and tear than those built from solid parts.

The laws of physics dictate just where such liquid-metal machines will be most effective. The forces produced by surface tension dominate at small scales. At larger scales they are eclipsed by those generated by electromagnetism, on which conventional motors rely. This means that liquid-metal engineering will be most useful for objects that are roughly centimetre-size and below. As this is the regime where maintenance and repairs are the most fiddly and costly, such a feature is good news.

Researchers are exploring their use in "labs-on-a-chip", which are portable devices for conducting a variety of scientific tests in the field, far from conventional laboratory infrastructure. Some scientists have crafted them into modular antennas, whose resonant frequencies can be changed by adjusting their shape. Others hope to weave them into soft robots, where they could act as artificial muscles, or to use them in 3D-printed electronics.

And even though they will likely be limited to smaller devices, the appeal of liquid metals is easy to see. Blobs of liquid experience none of the friction-induced wear-and-tear that eventually causes gearboxes, valves and the like to break down. Any damage or disruption they suffer is naturally self-healing. Gallium alloys, moreover, are easy to make, harmless to the touch, and have very low rates of evaporation, meaning that users are unlikely to inhale them accidentally. Just the ticket, in other words, for creative engineers. ■

Crowd behaviour

Of architects and bull-running

A Spanish tradition offers insight into how crowds behave

EVERY YEAR thousands of people converge on the city of Pamplona, in north-eastern Spain, for the opportunity to run for their lives as six fighting bulls are released to charge through the town. There are dozens of injuries every year, and there have been at least 15 deaths recorded since 1910. But the event is of interest to more than just adrenaline junkies and animal-rights activists. A paper just published in *Proceedings of the National Academy of Sciences* describes the insight the event offers into the psychology of panicked crowds.

That is a useful topic to explore. Architects, civil engineers and urban planners must try to work out how people will behave in the event of a disaster like a fire, a flood or a terrorist attack so they can design their creations to avoid potentially lethal crushes. Unfortunately, solid information is hard to come by. Ethics-review boards, after all, are likely to frown on researchers putting volunteers into deadly danger simply to study how they might behave. But Daniel Parisi, a physicist and computer scientist at the Technical Institute of Buenos Aires, and the paper's lead author, realised that the Pamplona bull-runs offered the perfect natural experiment.

Dr Parisi and his team went to two different rooftop locations in Pamplona in July 2019, and recorded footage of the runners as the animals were released. A wave of people running at top speed raced past their cameras a few seconds ahead of the bulls. The researchers brought their recordings back to the lab to calculate the velocities of the runners, the density of the crowd and the probability of a runner tripping and falling. They also examined the trajectories of the bulls, the responses of individual runners as bulls came near to them, and the relationship between runner-group density and velocity.

Perhaps unsurprisingly, the researchers found that runners picked up speed when the bulls drew near. Less expected was the finding that the speed of individual runners increased with the density of the crowd. At the crowd's maximum speed of around four metres per second, density reached roughly one pedestrian per square metre. This finding is at odds with a long-held assumption in architectural and urban-design circles that people will slow their pace as group density goes up, in order to lower the risk of a collision, which could lead to a fall and, perhaps, injury or death as a runner is trampled by others. Dr Parisi's data suggests that groups of fast, crowded runners are indeed at risk: of 20 people who fell, all did so within a fast-moving, dense group. Most (14 of the 20) involved two or more people, with one person tripping another.

Yet it seems that, in the heat of the moment, people pay little heed to the danger of colliding with each other, and do not slow down. The onus therefore falls upon urban designers to work out how best to plan the construction of future alleys, tunnels, bridges and other passages that restrict flow. The only option may well be to make them wider.

What you don't want to happen