FLUID MECHANICS

Mist opportunities

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From the fixative properties of hairsprays to the stickiness of filaments on beetles' feet, the wetting of flexible fibres with droplets of liquid is a universal phenomenon — but one we know surprisingly little about. On page 510 of this issue, Duprat *et al*. formulate rules to describe how mists of droplets interact with flexible fibre arrays (C. Duprat, S. Protière, A. Y. Beebe & H. A. Stone *Nature* **482,** 510–513; 2012).

The researchers began with the simplest possible model: the interactions of water droplets with a pair of closely aligned, flexible glass fibres that were clamped at one end but free to bend at the other. They observed that a droplet deposited close to the clamped ends adopts one of three forms: it could remain as a tight, spherical bridge between the filaments, or, depending on the conditions, it could either partially or completely spread along the fibres, in the latter case causing them to coalesce.

On further investigation, Duprat *et al*. found that six physical parameters control droplet shape and spreading; they include fibre geometry, the distance between the fibres, and the fibres' mechanical properties. The authors also identified a critical droplet volume above which fibres do not coalesce, and a second critical volume at which droplet capture by fibres is maximized.

The team went on to explore the wetting of a natural fibre array by spraying a goose feather with oil droplets and observing the effects on the barbules (filaments projecting from each barb of a feather). They found that their theoretical model held up — small droplets spread along the barbules and caused barbule clumping, whereas larger droplets did not spread and could be easily dislodged — despite the roughness of the feather's barbules and the chemical affinity between the droplet and the barbules' surfaces.

Duprat and colleagues' discoveries suggest that the mechanical properties and spatial organization of biological fibre arrays may have evolved to optimize interactions with liquid droplets, and so enhance functions such as adhesion, dew collection and self-cleaning. The work also offers opportunities for improving the performance of technological wetting systems — for example, droplet volumes in sprays could be engineered to fine-tune their wetting interactions with relevant fibres. **Rosamund Daw**

had at its source. This means that, for the same dust temperature, observing the dust emission at the longer wavelengths corresponds to observing an epoch when the Universe was smaller, and hence younger. By measuring the dust at different wavelengths, Planck can track the emission from star-forming galaxies as a function of cosmic time. Planck's observations[2] suggest that most of the emission in the longer-wavelength bands comes from galaxies that formed at a time when the Universe was less than 2 billion years old (the age of the Universe today is approximately 14 billion years).

To achieve this measurement, the Planck team performed[2] a sophisticated software analysis called component separation. This was required because these wavelength bands contain radiation from many other sources, mostly the Milky Way, but also the cosmic microwave background (CMB, relic radiation from the early Universe glowing at 2.7 K). The strengths of these sources vary differently as a function of wavelength. By combining Planck's nine wavelength bands with additional external measurements, the team was able to separate the cosmic-infrared-background component from the other sources of radiation. The authors found[2] a broad agreement in results between different areas in the sky, which had been specially chosen for having low radiation from our Galaxy, suggesting that the component separation was successful.

The emission from the Milky Way is not just a contaminant of the cosmic infrared background; it also contains some surprises of its own. One of these relates to the 'anomalous microwave emission' at centimetre wavelengths. This has been known about for a few years, but its origin has been controversial. In particular, although this radiation has been observed[4] to correlate with the emission from small dust grains in the Galaxy, simple models of thermal emission from dust could not explain its wavelength dependence. However, if the dust particles are spinning at high rates, they can radiate at a wavelength that relates to their spinning frequency and size. In this spinning-dust model, the emission occurs over a relatively narrow range of wavelengths that happens to coincide with the longest-wavelength band of the Planck observatory. Planck's observations of emission from the Milky Way provide[5] strong support for the spinning-dust model.

Not all of the results from Planck are related to dust radiation. Light propagating through hot gas can be scattered off electrons zooming around these high-temperature regions. The result of this process, named the Sunyaev–Zeldovich (SZ) effect after the two Russian scientists who first proposed[6] it, is that longer-wavelength light is shifted to shorter wavelengths. When viewed against the background provided by the CMB radiation, this effect leads to a dark hole at longer wavelengths at the position of a gas clump on the sky. Similarly, it causes a bright peak of light at shorter wavelengths at the same position.

With Planck's many wavelength bands, both of these features can be observed, leading to a convincing detection of the SZ effect. The sources most likely to provide a detectable SZ signal are the most massive galaxy clusters, which contain huge amounts of some of the hottest gas in the Universe. The Planck team found[7] nearly 200 cluster candidates with this technique, of which about 20 were previously unknown. Most of these have subsequently been confirmed as real clusters by follow-up studies, including X-ray observations[8] with the XMM-Newton satellite. Combined analysis of these data provides detailed information about the gas density and temperature distribution in the clusters, resulting in a better understanding of the processes that led to their formation.

These new results[7] demonstrate that it is possible to find clusters of galaxies with the SZ technique even for surveys looking at the entire sky, in contrast to previous SZ detections — by the South Pole Telescope[9] and Atacama Cosmology Telescope[10] — that searched smaller patches of the sky. Ultimately, the SZ method will allow clusters to be observed at a much larger distance from Earth than is possible with other methods, such as X-ray emission. One exciting application of the SZ approach would be to probe the growth of the largest (and thus rarest) structures at early times. Such observations would provide a measurement of the different components that make up the Universe and of the size of the initial density fluctuations that eventually