ASTRONOMY

Gazing Through the Dust

Galaxies undergoing vigorous bursts of star formation are often optically concealed by dust but appear luminous at longer wavelengths because the dust absorbs the light of the stars and re-emits it in the far infrared. If the galaxies are distant, they are detected at submillimeter wavelengths near Earth, because the far-infrared light gets stretched (or redshifted) by the cosmological expansion of the universe. In this way, hundreds of dusty, star-forming submillimeter galaxies have been detected over the past decade. Determining their precise distances from Earth, however, requires measuring a spectrum of their starlight, which is often too faint to detect.

As a proof of concept for circumventing this problem, Wei et al. used the new receiver at the IRAM 30-m radio telescope to look for CO emission lines—arising from the molecular gas that fuels star formation—from a submillimeter galaxy that was discovered in 1998 but for which it has not been possible to determine a distance. Their detection of two emission lines places the submillimeter galaxy SMM J 14009+0252 at redshift 2.93, or 11.4 billion light years away, and showcases a promising technique for determining the redshifts of submillimeter galaxies. — MJC

Astrophys. J. 705, L45 (2009).

ENGINEERING

Wide Yet Sensitive

In a displacement force sensor, there is an inherent tradeoff between sensitivity (which requires large deflections to detect weak applied forces) and bandwidth (which requires small deflections to accommodate a wide range of applied forces). Similar tradeoffs apply to sensing in more than one direction while keeping the device compact. Wood et al. sought to optimize these tradeoffs in force sensor design. They fabricated a three-dimensional sensor by folding a laser-patterned Invar sheet, reinforcing it with glass-filled epoxy, and soldering the tabs together. Numerical analysis revealed almost no coupling between the deformation responses along the orthogonal axes. The device proved more sensitive than expected from the modeling studies, because of a lower than expected stiffness, and the bandwidth was also affected by the weight of the adhesive used. The authors demonstrated the sensor's capabilities by simultaneously measuring the lift and drag forces from the flapping wing of a fly-sized robotic insect. — MSL

Smart Mater. Struct. 18, 125002 (2009).

SIGNAL TRANSDUCTION

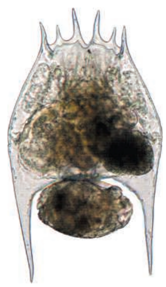
Single-Molecule Sensitivity

The external fertilization of sea urchin eggs relies on an extreme sensitivity of the sperm to chemoattractant molecules that guide the sperm toward the egg. In fact, Arbacia punctulata sperm can sense a single molecule of chemoattractant. Bönigk et al. show that such sensitivity is not limited to the receptor-type guanylyl cyclase that is located on the sperm cell membrane and detects the chemoattractant. This enzyme makes the second messenger cyclic guanosine monophosphate (cGMP), and the cGMP produced is detected with single-molecule sensitivity by K^+-selective cyclic nucleotide-gated (CNGK) channels. Binding to only one of the four cGMP-binding sites on the tetrameric channel was sufficient to open the channel. The authors also deployed a caged form of cGMP, in which photolysis breaks the cage and releases cGMP with a concomitant fluorescence signal. This reagent allowed them to estimate that less than 50 molecules of cGMP were formed in response to a single molecule of chemoattractant. Only a small fraction of these are likely to diffuse and bind to a channel because of competing binding sites and degradation pathways in the cell. The authors propose that other high-affinity receptors for neurotransmitters and hormones may also display single-molecule sensitivity. — LBR

Sci. Signal. 2, ra68 (2009).

ECOLOGY

Timing Is Everything



The mathematical description of coupled oscillations dates back to the 1665 analysis of pendulum clocks by Christiaan Huygens. Ecological models predict that populations of species in a community can exhibit similar oscillatory behaviors, giving rise to complicated patterns of synchrony and chaos in their dynamics. Benincà et al. provide an empirical confirmation of these predictions by studying a food web of phytoplankton prey and zooplankton predators that was maintained in the laboratory for 8 years. They observed that the chaotic dynamics of the populations were driven by the coupling of two predator-prey cycles, in which the larger phytoplankton species was eaten mainly by copepods and the smaller phytoplankton species was consumed by the relatively smaller zooplankton species—rotifers. Competition for resources between the phytoplankton species caused the predator-prey cycles to fluctuate out of phase, ultimately permitting the tenuous coexistence of the component species in the food web. Such principles may govern the longer-term, and hence less easily studied, dynamics of more intricate food webs involving longer-lived species. — AMS

Ecol. Lett. 12, 1367 (2009).

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