uterus. However, in humans and other primates circulating relaxin is present at 100-fold lower levels compared with that in the rat and pig, and only peaks during the first trimester. In clinical trials with recombinant human relaxin, the peptide hormone failed to show any effect on relaxation of the cervix. Not surprisingly, these results have proved something of a death-knell for interest in relaxin research.

Viewing relaxin as a hormone of late pregnancy is misleading. In humans, the peak in circulating relaxin during the first trimester coincides with implantation of the embryo, and recent experiments show that relaxin appears to be as crucial as progesterone for the induction of decidualization (the differentiation of the uterine stroma to accommodate the implanting embryo) (*5*). Circumstantial evidence supports the notion that disruption of circulating relaxin during early pregnancy is associated with loss of the fetus (*6*, *7*). Relaxin specifically induces the expression of vascular endothelial growth factor (VEGF) in the endometrium and, hence, is responsible for the formation of new blood vessels that are essential for embryonic growth and development (*8*). But the story does not end here for relaxin is secreted not only by the ovary during pregnancy, but also by many other tissues as a paracrine factor involved in the formation of new blood vessels after infarct or during wound healing (*9*). In addition, relaxin has marked effects on the dilation of blood vessels and is locally produced in the human heart to redress the cataclysmic consequences of congestive heart failure (*10*). Relaxin is a vasoactive hormone, but also restricts the formation of fibrotic lesions in humans and in different animal models (*11*). Thus, relaxin is far more versatile than a hormone involved only in reproduction.

In women, most of the relaxin in the circulation derives from the ovary. Like the sex steroid hormones, estrogen and progesterone, levels of relaxin decrease during menopause. Bearing in mind the typical symptoms associated with postmenopausal aging—fibrosis, wound-healing deficits, vasorestriction—we may be overlooking the possible therapeutic benefits of relaxin as a hormone replacement therapy.

In addition to identifying LGR7 and LGR8 as receptors for relaxin, Hsu and colleagues point out that LGR8 also may be the receptor for the closely related hormone RLF (*2*). They make this connection on the basis of the independent discovery that a mutation in the *LGR8* gene in mice results in failure of the testes to descend, the same abnormality that is seen in RLF-deficient mice (*12–14*). RLF is synthesized by Leydig cells in the fetal testis and appears to be responsible for the second phase of testicular descent by influencing the growth and differentiation of the cord that connects the testes with the lower abdomen. This peptide hormone is also made in large amounts by the Leydig cells of the adult testis (*15*, *16*), although its function in the adult male is not known. In the female, RLF is made by the theca cells of the ovarian follicles and by other tissues, and may be involved in ovarian follicle selection (*17*). Research on RLF is still in its infancy, but it is already clear that this hormone is secreted by diverse tissues and has several different functions.

The discovery of the receptors for relaxin and RLF should stimulate research into the molecular pharmacology of these hormones for which neither antagonists nor agonists are available.

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PERSPECTIVES: ASTRONOMY

Radio Noise from Dust Grains

Andrea Ferrara

In a galaxy like the Milky Way, about 0.1% of the visible mass resides in "cosmic dust"—tiny, silicate- and carbon-based particles with a mean radius of ~0.1 μm. Although it only makes up such a small fraction of the total mass, this dust plays an important role in galactic evolution: It provides suitable conditions for star formation, acts as a catalyst for the formation of molecules, and shields the molecules from damaging stellar ultraviolet radiation.

Energy absorbed by cosmic dust particles is typically converted into thermal energy and reemitted in the infrared at wavelengths of ~100 μm, where it can be observed and used as a powerful physical indicator of the physical conditions of the source. However, a paper in press in *Astrophysical Journal* reports the detection of a continuum signal at radio wavelengths (~3 cm) that can be attributed to dust beyond any reasonable doubt (*1*). What causes this unusual emission? And what are its implications?

Long before any observations of such emissions were reported, theorists suggested that they might exist. In 1957, Erickson (*2*) suggested a mechanism by which dust could produce nonthermal radio noise. If a dust grain residing in an interstellar cloud is bombarded with moderately fast atoms or ions, these collisions transfer angular momentum to the grains. Their rotational frequency may then reach values comparable with radio frequencies. Grains are usually charged and can behave as rotating electric dipoles if their centers of mass and of charge do not coincide—either because their shapes are irregular or as a result of statistical fluctuations in the charge distribution on the grain. Erickson postulated that under these conditions, spinning grains would emit observable radio waves.

Hoyle and Wickramasinge (*3*) revisited the problem in the context of galactic HII regions, that is, regions in the Milky Way where interstellar hydrogen has been ionized by photons with energies >13.6 eV emitted by massive stars. An ionized, magnetized gas as found in HII regions usually emits predominantly through synchrotron processes. But the authors speculated that nonthermal radio emission might be as important as synchrotron emissions for explaining the observed flux at gigahertz frequencies from HII regions.

After these early studies, the field remained essentially dormant, probably because the predictions could not be tested with existing observational tools. In the meantime, Purcell and Spitzer (*4*, *5*) set the theoretical basis for a better understanding of grain rotation. They showed that grains can rotate suprathermally, that is, with an energy much greater than kT (where T is the temperature of the system and k is the Boltzmann constant) as a result of torques acting on grain shape irreg-

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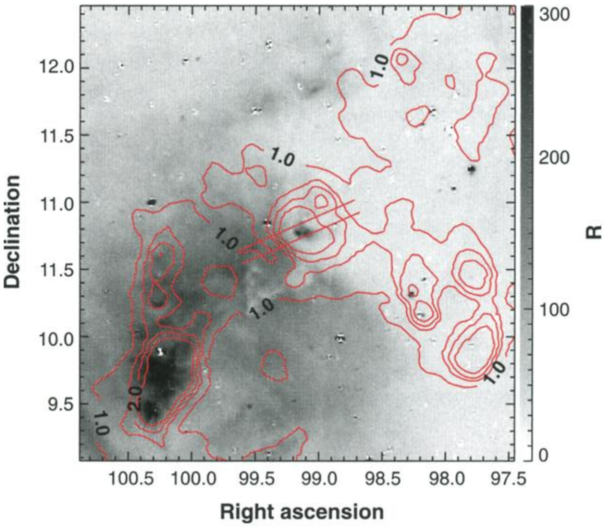
ularities. In this mechanism, random torques caused by photoelectric emission, photon absorption or emission, and H_2 molecule formation force the angular momentum of the grains to grow, eventually pushing rotational frequencies to values well above 10 GHz.

In 1994, Ferrara and Dettmar (*6*) rejuvenated the earlier work (*2*, *3*) and calculated emission spectra for radio-emitting dust from the free electron layer of galaxies (a thick, uniform, ionized gas layer in which stars are embedded in many nearby galaxies). The calculated spectrum was shown to peak at 10 to 30 GHz, depending on grain size distribution and the efficiency of the radiative damping of the rotation. More importantly, the predicted intensity of the radio emission was larger than that of free-free radiation (*7*) from the ionized layer and had a different spectral dependence. Hence, it should be detectable with experimental methodologies available at the time of the study.



Evidence for spinning grains. This composite image of the HII region LPH 201.663+1.643 shows evidence for radio emission from spinning grains. The gray scale is the image centered at the wavelength of the hydrogen H_α emission [rayleigh (R) units on the bar; 1 R = 10^6 photons cm^{-2} s^{-1}]. Contours are dust extinction levels. The region scanned during the study (*1*) is also shown.

The first observations rapidly followed, revealing (*8*, *9*) a substantial excess emission—the "mystery component" (*10*)—toward the North Celestial Pole at 14.5 and 32 GHz. Calculations with state-of-the-art grain models and physical properties of the interstellar medium (*11*, *12*) confirmed that the excess radio emissions could not be completely attributed to free-free radiation and were probably caused by cosmic dust.

In a very recent study (*1*), the observations were extended to lower frequencies (5, 8, and 10 GHz), providing insights into the overall spectral shape of the emission. Equally important, the authors were able to study a limited number of discrete sources, namely dark or infrared-selected interstellar clouds and HII regions. One of these sources, an HII region (see the figure), unambiguously showed the expected intensity and rising spectrum signatures of the "mystery" radio emission from spinning grains. A second candidate, a dark cloud, was also inconsistent with pure free-free emission, albeit at a lower confidence level.

These radio emissions from dust grains provide an important new tool for studies of the interstellar medium in galaxies. Future investigations with ground-based telescopes and satellites as PLANCK and MAP should be able to constrain the abundance of small grains, their spatial variations, and the degree to which they are aligned. The "mystery" emission could also represent yet another important foreground to be subtracted in experiments aimed at measuring the angular structure of the cosmic microwave background.

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PERSPECTIVES: ECOLOGY

Darwin and the First Ecological Experiment

Andy Hector and Rowan Hooper

The disappearance of species from Earth has been likened to the loss of rivets from an airplane (*1*). This vivid analogy has inspired ecologists to think about how changes in biodiversity affect the way that ecosystems operate. We tend to view this research, which is currently one of the most active areas in ecology, as relatively new, but as with many things in biology, Darwin got there first (*2–4*). In *The Origin of Species* (*3*) Darwin says, "It has been experimentally proved that if a plot of ground be sown with one species of grass, and a similar plot be sown with several distinct genera of grasses, a greater number of plants and a greater weight of dry herbage can thus be raised."

Darwin clearly identifies that ecological differences between species can make communities both more diverse and more productive. But which experiment was he referring to? Unfortunately, *The Origin of Species* does not contain references as it was intended only as an abstract for an unfinished longer work, *Natural Selection*, which was put to one side after Wallace independently conceived the same theory of evolution. An edited version of *Natural Selection* based on Darwin's writings was eventually published in 1975 complete with references (*5*). The work Darwin refers to comes from an 1826 article by the Duke of Bedford's head gardener, George Sinclair (*6*). In his article, Sinclair describes experiments conducted at Woburn Abbey in Bedfordshire, England, at the start of the 19th century. The results of these experiments were originally published in *Hortus Gramineus Woburnensis* (*HGW*) (*7*).

The first edition of this book, published in 1816, describes an experimental garden designed to compare the performance of different species and various mixtures of grasses and herbs on different types of soil (see the figure). A plan of the experimental garden lists the plant mixtures grown in 242 plots, each 4 square feet, enclosed by boards set in cast-iron

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