Astronomy

A plenitude of pulsars

Globular clusters — thick clumps of very old stars lying just beyond the fringes of the Milky Way — seem a surprisingly fertile breeding ground for rapidly spinning neutron stars, or pulsars. Although these clusters, satellites of our galaxy, lie so far away that astronomers can detect only the brightest pulsars, a systematic search for pulsars within globular clusters has already pushed the tally to 20. The results suggest that a typical globular cluster may harbor at least 100 pulsars, most of which would be too faint to detect. Such an abundance is difficult to reconcile with conventional models of the evolution and dynamics of globular clusters.

In the latest discovery, reported in the July 5 NATURE, a research team from the California Institute of Technology in Pasadena identified two additional pulsars in a globular cluster designated Messier 15 by sifting through radio-wave signals captured at the Arecibo radiotelescope in Puerto Rico. Their find brings to three the number of known pulsars in that star grouping. Because the observed pulsars probably represent only a fraction of the total pulsar population, the identification of three especially bright pulsars in a single cluster suggests that pulsars are quite common in globular clusters, the researchers say.

One of the newly discovered pulsars apparently has a companion — either another neutron star or a massive white dwarf — in a highly elliptical orbit. Monitoring pulse arrival times from this binary system may enable astronomers to check for various relativistic effects, including the emission of gravitational radiation as the orbit's period slowly decreases.

"Now that we know where and how to look for millisecond pulsars, we can expect the stream of discoveries to become a torrent," comments Charles D. Bailyn of Yale University in New Haven, Conn., in the same issue of NATURE. "There should soon be many more opportunities to exploit the unique tests of gravitational theory provided by pulsars, as well as to learn more about the evolution of stars and star clusters."

Rotating with the sunspot cycle

Tracking the progress of sunspots across the sun's face provides a handy way of studying how rapidly the sun rotates on its axis. Early studies showed that equatorial regions of the sun rotate somewhat faster than regions near its poles. More recent work has indicated that the rate of rotation also seems to depend on the size, shape and relative position of sunspots and other markers of solar activity. Now, David H. Hathaway and Robert M. Wilson of the NASA Marshall Space Flight Center in Huntsville, Ala., present new evidence that the sun appears to rotate more rapidly when fewer sunspots mark its surface.

Hathaway and Wilson carefully analyzed published sunspot rotation rates for the period from 1921 to 1982. They discovered that over the course of each solar cycle, the most rapid rotation usually occurred at the sunspot minimum. Moreover, when the sun's southern hemisphere had fewer spots than the northern hemisphere, it rotated more rapidly than the northern hemisphere. And, averaged over each solar cycle, the sun as a whole appeared to rotate more rapidly during cycles with fewer sunspots and smaller sunspot area.

"Rapid rotation is observed when and where the sunspot area is small," the researchers conclude in the July 1 ASTROPHYSICAL JOURNAL. The size of the effect suggests the sun may rotate about 0.5 percent faster during periods when few sunspots appear, such as the 70-year Maunder minimum.

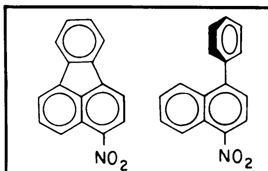
"The source of this effect remains uncertain," Hathaway and Wilson say. "An explanation for the decrease in rotation with increasing sunspot area will require a better understanding of the dynamics of the solar interior and the formation of sunspot magnetic fields."

Environment

NO_xious PAH-lution: Precarious prediction

Chemists keep looking for generic rules tying a compound's features to its toxicity. Rules that apply to all known members of a chemical class offer a good chance of accurately predicting the toxicity of new members as they are discovered. Toxicologists thought they had one such rule for the "nitro-PAHs" found in urban air, says William A. Pryor, an environmental chemist at Louisiana State University in Baton Rouge. These air pollutants form when nitrogen oxides (NO_x) marry into another family of ubiquitous air pollutants, the polycyclic aromatic hydrocarbons (PAHs). But in a chance focus on one particular offspring of such a union, Pryor's team discovered the fallibility of that rule. They also found what they say appears to be a new route for nitro-PAH formation: free-radical reactions.

Several NO_x species, such as nitrogen dioxide, carry an odd number of electrons. Because of their unpaired, or odd, electron, such highly reactive species are called free radicals. Nitro-PAHs formed when nitrogen dioxide merges with PAHs through free-radical reactions differ greatly from those created in more conventional ways, the researchers found, and include some of the most mutagenic pollutants in urban soot. "So we're on the track of something that is environmentally important," Pryor says.



(3NF) (1P4NN)

The work also provides new clues to the toxicological significance of shape. Pryor's group studied nitro-PAHs based on three linked phenyl rings from which a nitrogen dioxide group dangles. Others had found that the mutagenicity of a nitro-PAH appeared linked to its reduction potential, or the ease with which it accepts an electron, Pryor explains. So the Baton Rouge researchers compared twin nitro-PAHs featuring identical chemical compositions and reduction potentials: 3-nitrofluoranthene (3NF) and 1-phenyl-4-nitronaphthalene (1P4NN). The only difference between the planar 3NF (left) and 1P4NN is a severing of one bond anchoring 1P4NN's top and bottom rings (right). Thus freed, the top ring twists out of the plane.

Though the molecules' low reduction potential suggested both should be strongly mutagenic in bacteria (a gauge of potential carcinogenicity), only 3NF was. In fact, the chemists report in the May/June CHEMICAL RESEARCH IN TOXICOLOGY, 3NF proved the most mutagenic compound they studied — and its twisted twin the most innocuous.

Pigments take their NO_x

Nitrogen oxides can chemically alter textile fibers, dyes and paints, but scientists have scant data on indoor NO_x levels or on which oxide species might damage artworks most. Now, preliminary data from an unpublished study indicate some pigments are vulnerable to "very very low" levels of nitric acid, says Lynn G. Salmon of the California Institute of Technology in Pasadena. Salmon observed that this pollutant — one of the more reactive NO_x species — not only causes fading but also turns one green pigment purple.

The pigment study follows an assay of nitric acid in five Los Angeles museums. In four museums, Salmon and her co-workers found that levels were quite low, at only a few percent of outdoor levels. The fifth, which opened its windows in summer, sometimes had indoor nitric acid concentrations approaching 40 percent of outdoor levels. However, even low indoor levels do not guarantee the safety of museum holdings, the researchers report in the July ENVIRONMENTAL SCIENCE AND TECHNOLOGY. They say an accumulation of nitric acid on surfaces — perhaps including artworks — appears to explain why one museum's indoor levels remained so low.