Turbulence over abundances of elements in stars

Among the most important of astrophysical data are the relative abundances of heavy elements in the atmospheres of stars. Comparing these figures for different classes of stars, astronomers build theories of the evolution of stars and the galaxy. The abundances give information about what elements are produced by nucleosynthesis within a given star. They also help indicate which elements may have fallen in from interstellar matter and which elements may be expelled into interstellar space. Detailed pictures of the stars lead to scenarios of galactic history. These scenarios include such items as what classes of stars are formed at what time in galactic history, and how the shape, appearance and physical and chemical composition of the stars and galaxy vary with time.

Two astrophysicists, G. Worrall of Cambridge University in England and A. M. Wilson of the Goddard Space Flight Center, now suggest that the basis on which these abundances have been measured may be erroneous. If so, theories of astrophysical evolution may need serious revision.

The abundances of elements are determined from the widths of their absorption lines in the spectra of the stars. As light generated at lower levels in the star proceeds outward through the stellar atmosphere, gases in the atmosphere absorb particular patterns of wavelengths. This produces a series of dark lines in the otherwise bright photographic print of the spectrum. Each element is identified by its own characteristic pattern of lines.

Abundances are compared by comparing the breadth of the lines of different elements. If all the gas atoms in the stellar atmosphere were standing exactly still, the lines would be very sharp. The breadth arises because the atoms are moving. Motion causes a Doppler shift in any given atom's absorption so that the wavelength is slightly to one side or the other of the rest wavelength. The result of many atoms moving with random velocities is a line of a certain breadth.

At the level where the stellar atmosphere is thick enough for the statistical laws of thermodynamics to apply—the state called local thermodynamic equilibrium—the breadth of the lines can be related to the number of atoms present. The joker is that the measured line breadths appear systematically too great to be explained solely on the basis of thermal motions. Astrophysicists therefore introduced the concept of microturbulence, saying that there are nonthermal motions present that contribute to the line broadening.

Worrall and Wilson object to microturbulence on the ground that it is a fudge factor invoked without any other evidence of its presence simply to make the observations come out the way people wanted them to. Furthermore studies of the sun are beginning to show evidence against the existence of microturbulence, and the sun is considered a very representative star. In the March 3 NATURE, Worrall and Wilson urge a reconsideration of the question of microturbulence and the elemental abundances.

Naturally such a challenge to basic dogma will not be unchallenged itself. In the same issue of NATURE, Bernard E. J. Pagel, a spectroscopist at the Royal Greenwich Observatory, publishes a tut-tutting reply. The basis of Pagel's counterargument is that all does not depend on microturbulence. There are other bases on which the excess broadening can be explained and there are cross checks that can rescue belief in the abundances themselves, he says.

On the other hand, commenting editorially in its March 9 issue, the NEW SCIENTIST considers both sets of opinions and asserts that the basis of Worrall and Wilson's critique remains. As the news spreads, more and more astronomers are likely to get into the fight. □

Detection of gravity waves using earth as antenna

As a result of the experiments of Joseph Weber of the University of Maryland, whose claim to the observation of gravitational waves is now almost three years old (SN: 6/21/69, p. 593), more and more scientists are beginning to believe in them and look for them. From Dror Sadeh of Tel Aviv University now comes a claim of independent observation of gravitational waves.

Gravitational waves involve the forces of gravity similarly to the way electromagnetic waves involve electric and magnetic forces. Like electromagnetic waves, they can carry energy from place to place and yield information about gravitational processes going on in distant places. The existence of gravitational waves is thus of interest to astronomers and cosmologists not only because they would prove part of Einstein's general relativity theory but also because of the information they could bring about the universe.

Just as the passage of electromagnetic waves can cause electrical charges in a piece of matter to vibrate, so gravitational waves can cause gravitational charges to vibrate. Since every body is gravitationally charged, all masses should feel this effect, but it is so minute that to detect the waves large bodies are necessary for their cumulative effect to be measurable (Weber has used aluminum cylinders weighing tons.)

As Weber pointed out long ago, the earth itself could be a gravitational wave antenna. It would take a very sensitive seismograph to record earth vibrations as minute as gravity waves would cause and to distinguish them from the other microseisms that the earth is continually subject to.

One way to make the determination is to look for a signal from a source that the investigator expects to give off gravitational waves. Theory can then be used to calculate the frequency and the strength of signal that might be observed. Such a possibility lies at hand in the pulsars, and Sadeh used it.

Pulsars are astronomical bodies that give off strong, swiftly pulsed radio signals. The characteristics of their radio signals have led astronomers to believe that they are massive, enormously dense, very compact neutron stars that rotate very rapidly. There are ways in which such bodies can emit gravitational waves. Since the density of neutron stars is very high, the waves will be strong, perhaps strong enough to shake the earth. The regularities of physical processes in the pulsar could lead to periodicities in the gravity-wave signal that would identify it as a pulsar's.

Sadeh announced that he has found such a signal with equipment located in a cave near Eilat, Israel. It took four months of observation.

According to his statement the observation goes to prove not only the existence of gravitational waves but also the current theoretical picture of pulsars. □