

convection zone can be estimated as 3×10^7 erg/cm² sec, though the numerical result is highly uncertain because of its great dependence on the turbulent velocity field. The spectrum of this noise is a broad band with maximum near the frequency of 0.01 cps. The waves propagate in the so-called "fast" mode, and become increasingly magnetohydrodynamic in character as they run out through the chromosphere, because of the negative density gradient. Little if any energy is emitted by the hydrogen convection zone in the "slow" or "Alfvén" modes, and these modes are in addition strongly absorbed in the photosphere. The cross sections for collisions between neutral atoms and ions in the chromosphere are large, and as a result the dissipation of the fast-mode waves by the frictional damping mechanism is very small. The waves build up to shocks, and the dissipation of these shocks is the main energy source for the chromosphere. The dissipation of the shocks is worked out using a similarity principle, in a way analogous to the Brinkley-Kirkwood theory of the dissipation of pure gas-dynamic shocks. At great heights, where the magnetic field dominates, the shocks become weaker, the dissipation decreases, and the rays are refracted back downward toward the photosphere. However, at these heights collisions between shocks must be expected to feed some energy into the slow mode and Alfvén mode, and these modes then propagate straight up the magnetic lines of force, with essentially no weakening by refraction, and carry energy into the corona. The plages are regions of larger magnetic field, where the refraction and shock-collision effects are more important; in addition there probably is extra generation of noise in the hydrogen convection zone below them.

The Frequency of Double Galaxies in Clusters.

THORNTON PAGE, *Van Vleck Observatory, Wesleyan University, Middletown, Connecticut*.—Systematic identification of double galaxies on Palomar Atlas prints now underway at the Van Vleck Observatory is expected to provide statistical evidence of the manner of formation and stability of these systems. It is necessary, of course, to estimate and deduct the number of "optical pairs," a quantity that will vary widely with surface density of individual objects (e.g., in clusters).

The classical formula due to G. Polya (*Astron. Nach.* 208, 175, 1919) is generally used (Holmberg, E., *Lund Ann.* No. 6, 1937; Page, T., *Astrophys. J.* 116, 63, 1952) to argue that $N_2^*(m, S)$, the total number of observed pairs of magnitude less than m and of separation, S , is far greater than $N_2(m, S)$, the number expected on chance over the whole sky. Actually, the expected number in a limited area will deviate widely from the mean because of variation in the surface density, $n_1(m)$, the number of single

galaxies of magnitude less than m per square degree.

Applying Polya's formula for the probability that an individual galaxy in a random distribution will have its nearest neighbor between θ and $\theta + d\theta$ radians, $W(\theta) d\theta = 2n \sin\theta \cos^{2n-1}\theta d\theta$, one finds that the number of "unambiguous chance pairs" per square degree is expected to be

$$n_2(m, S) = \pi n_1^2(m) S \exp [-2\pi n_1(m) S^2].$$

Subtracting this from the observed surface density of pairs, we have the estimated number of physical pairs in a cluster, and, if spherical symmetry is assumed, the space density, $d_2(m, S)$. Allowing for the projection of space separation, R , into the projected angular separation, S , this yields the frequency distribution of R among double galaxies in a cluster.

Furthermore, $d_2(m, S)$ may be compared with the space density of individual galaxies in the cluster, $d_1(m)$. If the formation of physical pairs is due to capture, d_2 will be proportional to d_1^2 , a relation subject to observational verification, and the constant of proportionality is related to the velocity dispersion and past history of the cluster.

A Hydrogen-Line Interferometer. V. RADHAKRISHNAN, D. MORRIS, AND R. W. WILSON, *California Institute of Technology, Pasadena, California*.—A new and promising technique for the study of interstellar 21-cm absorption has recently been tried at the Caltech Radio Observatory. The twin 90-foot paraboloids were operated in a narrow-band interferometer arrangement at 1420 Mc. The fringe pattern obtained with the antennas tracking a point source had an amplitude proportional to the "visibility" of the source within a 6-kc bandwidth at a frequency which could be continuously varied by tuning the second local oscillator.

An improvement in sensitivity over single-dish operation was obtained by virtue of the increased collecting area and the absence of switching. The real merit of the system, however, for absorption studies, was in that it made the difficult determination of the "expected" profile redundant. The emission from the extended hydrogen clouds was resolved out and the amplitude versus frequency pattern obtained was essentially the spectrum of the point source within the beam. It was possible, for example, to clearly detect an absorption feature at +4 km/sec in the spectrum of 3C-123, whose intensity is only one-fiftieth that of Cas A. Parametric or other low-noise amplifiers should bring a vast number of point sources within reach of such investigation.

The sources Cas A, Cyg A, Sgr A, and the Crab, Orion, and Omega nebulae were observed with the interferometer. In most cases there were small but significant differences from single-dish values in optical depths and/or linewidths. These differences