sity of Michigan.—NGC 4486-B, called a compact galaxy by Zwicky, is a Virgo Cluster E0 galaxy 7:3 north preceding NGC 4486 (M87). In this study, some physical properties of NGC 4486-B have been determined.

The distribution of photographic surface brightness was derived from microdensitometer tracings of several 100- and 200-in. plates. Typical atmospheric-instrumental profiles had dispersions of 1"–1:5. The intensity profile of M87, photoelectrically determined by Baum, was used for calibration. The surface brightness decreases with distance from the image center, r , approximately as $r^{-1.9}$ for $2'' \lesssim r \lesssim 4:8$ and $r^{-3.1}$ for $4:8 \lesssim r \lesssim 13''$. The region $r \lesssim 4:5$ has a flatter brightness gradient relative to the region $r \gtrsim 4:5$ than is predicted by de Vaucouleurs' empirical relation for the brightness distribution of an elliptical galaxy. King's empirical relation for the brightness distribution of a globular star cluster approximately fits the observations when a core radius of 1" and a limiting radius of 30" are adopted.

A total mass $M = 5 \times 10^{10} M_{\odot}$ is deduced from the virial theorem, when one employs the adopted brightness profile based on King's relation, an internal radial-velocity dispersion of 370 km/sec (determined by Minkowski) and the following two assumptions: (1) The mass and luminosity have identical spatial distributions. (2) The internal velocity dispersion is isotropic and independent of stellar mass. The total apparent magnitude derived from the observed brightness profile is $m_{pg} = 14.2$. This corresponds to an absolute magnitude $M_{pg} = -16.7$. The resulting mass-to-light ratio is $M/L_{pg} = 80 M_{\odot}/L_{pg\odot}$.

NGC 4486-B may be a tidally limited satellite of M87. The estimated masses, 7:3 projected separation, and 200 km/sec radial-velocity difference of these galaxies suggest that they probably form a bound pair. The observationally derived limiting radius of NGC 4486-B is consistent with that based on the theoretical formula for tidal cutoff radius.

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KO Aquilae as an Example of Close Binary Systems with Undersize Subgiant Secondaries in Pre-Main Sequence Contraction. IAN W. ROXBURGH, *High Altitude Observatory, and King's College, University of London.*—The hypothesis is advanced that close binary systems with an undersize subgiant secondary are in the pre-main sequence evolutionary phase, and applied to the system KO

Aquilae. Since KO Aquilae is a single spectrum binary a complete description of the system can be obtained by supposing that the primary is contracting towards the main sequence, and the age of the system is found to be 3.5×10^{13} sec, the mass of the primary $2.9 M_{\odot}$ and the secondary $0.58 M_{\odot}$. The radius of the primary is found to be $2.6 R_{\odot}$ and that of the secondary $2.1 R_{\odot}$, while the distance between the mass centers is $13 R_{\odot}$. To confirm our hypothesis we compute the radius of a star of $0.58 M_{\odot}$ after 3.5×10^{13} sec and this is found to lie between $1.9 R_{\odot}$ and $2.3 R_{\odot}$, in good agreement with the previous determination. The angular momentum of the system is computed and is found to be in satisfactory agreement with the predictions of the fission theory as advanced by Roxburgh (1965).

Review Paper: A New Era in Cosmology: The Use of Radio Galaxies, Quasi-Stellar Sources and Quasi-Stellar Galaxies as Probes. ALLAN R. SANDAGE, *Mount Wilson and Palomar Observatories.* (Read by Roger Lynds.)

Stellar Interactions and the Evolution of Galactic Nuclei. WILLIAM C. SASLAW AND LYMAN SPITZER, JR., *Princeton University Observatory.*—Interactions among stars affect the evolution of compact, nearly spherical galactic nuclei. In order of increasing influence, these interactions are gravitational radiation (an exact two-body solution is found), tidal encounters, and stellar collisions. Initially, loss of high-velocity stars and energy dissipation in tidal encounters cause the system to contract. As the collision frequency increases, much gas is liberated. The fractional mass loss per collision ζ is evaluated on a very simple model considering only the energy and momentum of colliding mass elements, neglecting all hydrodynamic effects. Mean values of ζ range from 0.03 for a rms stellar velocity V_* of 1400 km/sec to about 0.10 for $V_* \approx 10,000$ km/sec. Nuclear explosions in which increased nuclear reactions double the energy density of colliding mass elements in a time $= 2R_*/V_*$ occur for $V_* \approx 3000$ km/sec in head-on collisions. Decrease of the stellar velocity resulting from an off-center collision is negligible. The liberated gas radiates, cools, and falls to the center of the system. Angular momentum produces a flat disk whose density increases until new stars form. A typical disk has a density of about 10^9 atoms/cm³ and a thickness of several hundred a.u. Newly formed stars absorb kinetic energy from stars in the nucleus and the contraction accelerates until the relaxation time substantially exceeds the time required for a star to be destroyed by collisions. For typical parameters, initial angular momentum does not substantially inhibit

contraction. A system of 10^8 stars has a peak luminosity of about 10^{45} erg/sec and a radius <1 pc. Later, stars formed in the disk remain there and as the spherical system flattens its luminosity decreases. The energies radiated resemble those of quasi-stellar radio sources, but it is uncertain whether existing nuclei have evolved to the required compactness.

The Evolutionary Status of Dwarf Emission B Stars. TH. SCHMIDT-KALER, *David Dunlap Observatory*.—New theoretical models computed by P. Demarque and I. Iben have been used to calculate the onset of rotational instability and consequent mass loss of rapidly rotating stars. This instability occurs during a short contraction phase coinciding with the dying out of the convective core and the formation of a hydrogen-burning shell. (A similar suggestion has been made by Crampin and Hoyle, *Monthly Notices Roy. Astron. Soc.* 120, 33, 1960.) During this contraction a rapidly rotating star must get rid of excess angular momentum. It may do so by three mechanisms:

(a) By transport of momentum through magnetic fields. In order to be effective this requires a deep hydrogen convection-zone which does not exist for $M > 1.5M_{\odot}$.

(b) By transport of momentum through particles (stellar wind). The time scale of this process is long compared to the main-sequence lifetime of a B5 star.

(c) By equatorial mass loss and formation of shells. A mass loss of 3% is sufficient to allow the star to develop all along its way from the zero-age main sequence.

The development of rotational instability is governed by $\omega^2/2\pi G\rho$. This quantity, normalized to 1 at the zero-age main sequence as a function of time (normalized to 1 at the onset of secondary contraction), shows much the same behavior for stars of different masses. The rate of mass loss is $6.10^{-8}M_{\odot}/\text{yr}$ for B0, $1.10^{-8}H_{\odot}/\text{yr}$ for A0 in the secondary contraction; it is about 200 times greater than in the main sequence and pre-main sequence. An observable shell is expected only during secondary contraction and in the Hayashi phase. The maximal mass lost is about 0.5% near the main sequence and 2.5% during secondary contraction. The time spent in contraction increases from 2.4% at B0 to 5.3% at A0 while the initial $v_{\text{rot}}/v_{\text{crit}}$ decreases a maximum frequency of dBe stars of nearly 4% is expected at B3–5.

For masses below $1.25 M_{\odot}$ there is no convective core, therefore no secondary contraction, and no shells expected for stars later than F5. The model also accounts for the low dispersion of the absolute magnitudes (aspect effects of rotating stellar atmos-

phere taken into account), and for the behavior of the rotation velocities of emission as compared to nonemission B stars.

In order to test the theory, all stars in open clusters known to have Balmer-like emission (exception only class I supergiants) have been picked out, altogether 54 stars in 29 clusters. *UBV* photometry (partly taken from *Naval Obs. Publ.* 17, Pt. 2) shows that more than 90% are in the position expected from theory. It is noted that most of the Be stars and virtually all M supergiants of the double cluster belong to χ Per.

The mechanism underlying the emission phenomenon in supergiant B stars should be fundamentally different from that considered presently for the dBe stars (location in the H-R diagram Balmer-like emission observed only at $H\alpha$).

It is concluded that dwarf emission and shell stars represent a transitory phase of normal evolution of rapidly rotating stars.

Observations of Total Eclipses of the Moon at a Wavelength of 1.82 cm. T. V. SELING, *The University of Michigan*.—Observations at a wavelength of 1.82 cm (16 500 Mc/sec) with the University of Michigan's 85-ft radio telescope were made of the total lunar eclipses of 30 December 1963, 25 June 1964, and 18 December 1964. Previously reported measurements of lunar eclipses indicated that a change in the surface brightness temperature of a few percent at most could be expected at this wavelength. In fact, Gibson reported that the change was less than 1°K at a wavelength of 0.86 cm and a decrease of about 10°K at 0.43 cm has been noted by Tolbert, Krause, and Dickinson. The mountainous region at the center of the moon was tracked steadily with the 3 min of arc pencil beam during the observations.

Results of the first two eclipses were inconclusive due to atmospheric and ground effects at the large zenith distances and the inability to observe the entire eclipse. A full eclipse curve was obtained at small zenith distances on 18 December 1964. The measured decrease in emission during this eclipse was $(4.1 \pm 0.7)\%$ of the central disk temperature after corrections for antenna efficiency and sidelobe effects were made. This corresponds to a change of $(10 \pm 2)^{\circ}\text{K}$ for an assumed central surface brightness temperature of 240°K . Duration of the total eclipse phase of the center of the moon was 130 min. The delay in the minimum of the 1.82 cm eclipse curve from the optical curve was not detectable within the observational uncertainty of 10 min.

This is the longest wavelength at which a change has been reported in the radio emission from the moon during a lunar eclipse.