Cepheus IV Association. G. A. H. WALKER, (introduced by R. M. Petrie), *Dominion Astrophysical Observatory*.—A group of 16 heavily reddened OB stars were found at $0^{\text{h}}, +67^{\circ}$ by Blanco and Williams (*Astrophys. J.* **130**, 482, 1959) close to the bright $H\text{ II}$ region S-278, on objective prism plates. Radial velocities, $H\gamma$ absolute magnitudes, spectral types, and central depths of the $\lambda 4430$ interstellar band have been derived from slit spectra for 13 of these stars at the Dominion Astrophysical Observatory. Two stars within $2'$ of the close central triplet of the association were also found to be OB stars. The spectral types agree well with those of Blanco and Williams. All the stars show poor lines and, according to $H\gamma$, are subdwarfs. This is supported by the prominence of the $\lambda 4686\text{ He II}$ line in absorption for the stars of B0 and earlier. The $H\gamma$ spectral type relation shows stronger $H\gamma$ than the Orion association, suggesting that Cepheus IV is very young. None of the stars is early enough in type to account for the extensive surrounding $H\text{ II}$ region, and it is suggested that there may be many association members too heavily obscured for detection.

The $H\gamma$ profiles seem to be variable for eight of the stars and the radial velocities show large variations. This suggests that they are similar to $\beta\text{ CMa}$ type variables although the latter are thought to be subgiants rather than subdwarfs.

The relative MKK class V luminosities give a very good correlation with V_0 but the relative $H\gamma$ luminosities do not. The 4430 intensities suggest that the E_{B-V} values are too large for four of the brightest stars. Adjustment of the V_0 values as indicated by the 4430 measures gives a satisfactory agreement with the $H\gamma$ luminosities. The $H\gamma$ luminosities and adjusted V_0 values give a distance of 860 pc. The MKK luminosities and unadjusted V_0 values give 808 pc.

General Circulation of the Solar Atmosphere. FRED WARD (introduced by Nannielou H. Dieter), *Air Force Cambridge Research Laboratories*.—Consideration of the solar rotation rate and its latitudinal variation leads to the hypothesis that the lower part of the solar atmosphere has large and dynamically important nonaxisymmetric horizontal circulations. This follows from an examination of the results of recent hydrodynamical model experiments and measurements of the energy balance in the terrestrial atmosphere. These results show how radically a thermodynamically driven circulation can be altered by rotation.

In this proposed model for the general circulation of the solar atmosphere, there are large-scale horizontal motions with east-west and north-south

components. These motions are variable in time, latitude, and longitude. Moreover, these motions are organized, that is, the latitudinal and longitudinal components are correlated. This correlation is such that fluid with an excess east-west velocity (excess angular velocity) will also tend to have an equatorward proper motion. Fluid with below average angular velocity will tend to have a poleward proper motion. In this way horizontal exchange processes operate to maintain a differential velocity profile, i.e., the equatorial acceleration.

A test for the existence of such a circulation from sunspot proper motion data yields positive and statistically significant results. These organized horizontal motions transport angular momentum (counter to the mean gradient) toward the equatorial regions. The rate of transport is such that if this mechanism were to cease, and all other processes continued unabated, the solar atmosphere would reach solid rotation in just a few rotations.

Photometric Investigation of the Galactic Clusters M37 and NGC 2420. FREDERICK R. WEST, JR., *Ames Research Center*.—The galactic cluster M37 is found to be a large, rich cluster with about 930 member stars brighter than apparent visual magnitude $V=17^{\text{m}}.7$ within a radius of $10'$ from the cluster center. Star counts show its linear diameter to be about 13.5 pc. The interstellar reddening is found to be constant across the cluster with the color excesses $E_{(B-V)}=0^{\text{m}}.27$ and $E_{(U-B)}=0^{\text{m}}.24$ adopted for the cluster stars. No ultraviolet excess is found for the stars of M37. The evolutionary deviation method of Johnson gives an (unreddened) distance modulus of $10^{\text{m}}.8 \pm 0^{\text{m}}.1$ and an age of 220×10^6 yr for the cluster. The color-magnitude diagram shows a well-defined main sequence and a red giant branch with 27 members. The luminosity function of the cluster main sequence closely agrees with the smoothed initial luminosity function of Sandage to $M_V=6^{\text{m}}$ mag.

The galactic cluster NGC 2420 is not as large and rich as M37, with a diameter of at least 10.5 pc and at least 500 members brighter than $V=19^{\text{m}}.0$. The cluster stars show a definite ultraviolet excess $\delta(U-V)=0^{\text{m}}.09$, but very little interstellar reddening, with color excesses $E_{(B-V)}=0^{\text{m}}.01$, $E_{(U-B)}=0^{\text{m}}.01$. The evolutionary deviation method of Johnson gives an (unreddened) distance modulus of $11^{\text{m}}.9 \pm 0^{\text{m}}.2$ and an age of 2×10^9 yr for the cluster. NGC 2420 turns out to be considerably older than M37. The color-magnitude diagram shows a main sequence $0^{\text{m}}.3$ wide in $(B-V)$ and a steep, well-defined red giant branch. A few cluster members appear to lie in the Hertzsprung gap region of the color-magnitude diagram. The luminosity function

of the cluster main sequence closely agrees with that of Sandage, steadily increasing to $M_V = 7$ mag.

The clusters M37 and NGC 2420 may provide additional evidence for the dependence of degree of ultraviolet excess on distance above the galactic plane.

Supernova Remnants in the Large Magellanic Cloud B. E. WESTERLUND, *Mt. Stromolo Observatory*, AND D. S. MATHEWSON, *CSIRO*.—Combined radio and optical observations lead recently to the identification of a small emission nebula in the Large Magellanic Cloud (LMC), N 49 in Henize's catalogue, as a supernova remnant (*Nature* **199**, 681, 1963). We have now identified a second emission nebula, Henize N 63A, as a supernova remnant. The optical position of N 63A is $5^{\text{h}}35^{\text{m}}37^{\text{s}}.9$, $-66^{\circ}03'51''$ (1950); its maximum dimension is $27''$ of arc. The radio position at 11 cm is within $0'.5$ of arc of the optical position (our experimental accuracy).

The flux density at 11-cm wavelength of N 63A is $1.2 \times 10^{-26} \text{ W m}^{-2} (\text{cps})^{-1}$ which is 25 times greater than that expected from the $H\beta$ intensity. A considerable portion of the radio emission could thus be of nonthermal origin. Observations at 11, 20, and 75 cm give a spectral index of -0.4 , which also indicates a nonthermal origin of the radiation.

Our observations suggest that both objects are remnants of Type II supernovae. N 49 would be 1000 times and N 63A several times stronger than Cassiopeia A when they had the same size. N 63A is most likely a member of a young association. There is an amazing similarity between the Cygnus Loop and N 49. Both show the same shell-like, filamentary structure, and N 49 will have intrinsically the same intensity as the Cygnus Loop when it has reached the same size. Previously, only supernovae of Type I have been found in irregular galaxies. Evidently, the LMC is sufficiently evolved for its youngest stars to have formed with the enrichment of heavy elements necessary for Type II outbursts. The emission-line spectra of N 49 and N 63A are similar to those of filaments of galactic Type II supernova remnants. In the red the lines appear in the following order of intensity: $H\alpha$, $[\text{Si II}]$, $[\text{N I}]$, $[\text{N II}]$. In the blue weak $H\beta$, $H\gamma$, and $H\delta$ lines and a strong $[\text{O II}]$ doublet have been identified in both objects, and a trace of $[\text{O III}]$ has been found in N 49. Radial-velocity differences of about 100 km/sec have been measured between parts of N 49.

It appears possible that N 49 and N 63A belong to the northern part of a shell (diameter 1000 pc). The southern part is seen as an arc of bright blue stars (Constellation III). The remainder of the shell

consists mostly of $H \text{ I}$ in which the two supernovae are embedded; the total mass is 3×10^7 solar masses. It is tentatively suggested that this shell may be the remnant of a Type I supersupernova suggested by Shklovsky to appear among the first generation stars in irregular galaxies or of an object of the type postulated by Hoyle and Fowler to account for the radio emission in galaxies.

Evidence for a Comet Belt beyond Neptune. FRED L. WHIPPLE, *Smithsonian Astrophysical Observatory and Harvard College Observatory*.—Certain theories of planetary formation lead to the possibility that a stable belt of comets exists beyond Neptune near the plane of the planets. This belt would not be easily visible nor would it be a significant source of the observed comets. It would, however, exert a gravitational effect on the motions of the outer planets. A theory has been developed and calculations made to ascertain the effect of such a comet belt on the motions of Neptune, Uranus, and Pluto. The theory accounts for the outstanding residuals in Neptune's latitude (L. R. Wylie to 1938) slightly better than the previously assumed attraction attributed to Pluto. Calculated effects in the longitudes of the three planets and in the latitudes of Uranus and Pluto are smaller than the observed residuals from present orbits.

Since Pluto appears far too small to produce the gravitational effects attributed to it, the existence of a comet belt appears reasonably probable. Among a large possible range in solution, a mass of 10 to 20 earth masses in the region 40 to 50 a.u. from the sun and inclined at 3° to the invariable plane of the planets is consistent with the latitude residuals for Neptune. From modern definitive orbits of Neptune, Uranus, and Pluto it is likely that a clear-cut answer could be obtained as to the reality of the comet belt.

It is interesting to note that such a comet belt could be the source of appreciable meteoritic material, particularly finer material, and may be contributing to the cloud producing the zodiacal light. If the observable comets are indeed found inadequate to maintain the dust in the zodiacal cloud, the source may well lie in the comet belt.

Hydromagnetic Equilibrium and Toroidal (Ring) Current Systems. MARVIN L. WHITE, *Air Force Cambridge Research Laboratories*.—A self-consistent steady state treatment is given for the interaction of an inexorable radial source of completely ionized hydrogen with a poloidal magnetic field. When the particles are directed radially outward (inward) the magnetic lines of force contract (expand) with in-