integral and complementary function. The arbitrary constants appear unambiguously in the complementary function, the nature of which is known from the properties of Keplerian motion. (See this issue, p. 287, for complete article.)

Evolution of Population II Stars. PIERRE DEMARQUE, *University of Illinois Observatory*.—The evolution of Population II stars into the red-giant region in the H-R diagram is investigated following a method recently used by Kippenhahn, Temesváry, and Biermann (*Z. Astrophys.* **46**, 257, 1958) who emphasized the importance of the structure of the hydrogen convection zone to determine the radius of red giants, and consequently their position in the H-R diagram.

(1) The central region forms an isothermal partially degenerate core of helium (Hoyle and Schwarzschild, *Astrophys. J. Suppl.* **2**, 1, 1955). Both the pressure of the degenerate electron gas and the non-degenerate nuclei are taken into account. The mass of the core increases as the star evolves.

(2) The energy generation is due to both proton-proton chain and carbon-nitrogen cycle. It is concentrated in a shell surrounding the helium core of the star.

(3) The opacity is that given by Keller and Meyerott (*Astrophys. J.* **122**, 32, 1955).

(4) The outer boundary conditions are obtained from a model atmosphere. The structure of the hydrogen convection zone is calculated assuming the mixing length to be of the order of the local pressure scale height.

The main purpose of this work is to investigate the differential effects of various chemical compositions on the evolutionary track. Calculations have been performed for stars of 1.2 and 1.0 solar masses. The results are compared to previous models and cluster color-magnitude diagrams.

Gas Streams in Barred Spirals. G. DE VAUCOULEURS, *University of Texas*.—The departures from circular motions observed by Burbidge *et al.* (*Astrophys. J.* **130**, 739, 1959) in NGC 2146 and by G. and A. de Vaucouleurs (*Astron. J.* **67**, 113, 1962) in NGC 4631 indicate the presence of large-scale streaming motions of the gas in barred spirals. The flow is directed outward from the nucleus along the bar and into the arms spreading out in opposite directions at both extremities of the bar. The maximum stream velocity is $V_s = 40$ to 50 km/sec and the total mass flow (on both sides of the nucleus) through the bar is $\mu(H) = 1.0$ solar mass per year in NGC 4631 and 1.4 sun/year in NGC 2146. The estimated $H\text{ I}$ and total masses ($\odot = 1$) are as follows:

NGC 2146, $\mathcal{R} \approx 1 \times 10^9 (?)$, $\mathcal{M} = 50 \times 10^9$ (for $\Delta = 12$ Mpc);
NGC 4631, $\mathcal{R} \approx 3 \times 10^9$, $\mathcal{M} = 24 \times 10^9$ (for $\Delta = 4.4$ Mpc).

Neglecting recirculation, i.e., gas ejection by stars, lower and upper limits of the ages of the galaxies for a constant injection rate $\mu(H)$ are $\mathcal{R}/\mu(H)$ and $\mathcal{M}/\mu(H)$; this suggests for both systems ages (since the beginning of star formation) of the order of $T \approx 1$ to 2×10^{10} years.

Neutral Hydrogen in Nearby Sc Galaxies. NANNIELOU H. DIETER, *Air Force Cambridge Research Laboratories and Harvard College Observatory*.—See this issue, p. 317, for complete article.

A Radio and Optical Investigation of Extragalactic Redshifts. N. H. DIETER, E. E. EPSTEIN, A. E. LILLEY, AND M. S. ROBERTS, *Harvard College Observatory*.—An investigation of the quantity $(\Delta\lambda/\lambda)_{\text{optical}}/(\Delta\lambda/\lambda)_{\text{radio}}$ is possible when extragalactic nebulae can be positively detected through the 21-cm spectral-line emission of $H\text{ I}$. In the course of the systematic radio investigation of extragalactic nebulae at the George R. Agassiz Station of Harvard College Observatory, 23 galaxies have been positively detected with the aid of the hydrogen-line maser and the 60-foot telescope. The radial velocity range of these observations extends from -345 to $+700$ km/sec. In addition to the 23 galaxies detected at Harvard, six additional galaxies detected elsewhere have been included in the analysis. For a total of 29 galaxies data are available for both optical and radio radial velocities. If the quantity $\Delta\lambda/\lambda$ is independent of wavelength, and if there are no systematic errors in the optical and radio measurements, then a plot of the optical versus radio velocities for the galaxies should generate a line with a slope of unity.

A least-squares determination of the regression of $(c\Delta\lambda/\lambda)_{\text{radio}}$ on $(c\Delta\lambda/\lambda)_{\text{optical}}$ yields a slope of 0.98 ± 0.04 (standard error) with an intercept of (0.9 ± 13) km/sec (standard error). The regression of optical velocities on radio velocities yields essentially the same values.

Holmberg (*Uppsala Medd.* No. 138, 1961) has suggested that there may be a systematic error in the optical determination of radial velocities of galaxies. The present data indicate that optical radial velocity determinations agree with radio determinations for nearby galaxies. This result does not necessarily contradict Holmberg's results since the sample of galaxies available for this study covers a relatively small range in radial velocities. Further, according to Holmberg's analysis the presence of emission lines in optical spectra would reduce the effect of systematic errors in optical radial velocities; most of the