Yerkes Observatory material is $+0''.054 \pm ''0.005$ p. e. This value, combined with trigonometric parallaxes determined at three other observatories, gave a final value for the absolute parallax

$$\pi = +0''.047 \pm ''0.005 \text{ p. e.}$$

The final values for the parallax, the three orbits, and a mass ratio determined in the present study for the A-B system $m_A/(m_A + m_B) = 0.53$, yielded the following masses for the four components:

$$\begin{array}{ll} m_A = 1.0 \odot, & m_C = 0.5 \odot, \\ m_B = 0.9 \odot, & m_D = 0.7 \odot. \end{array}$$

Stars A and B are of approximately normal mass for their luminosities, as judged by the mass-luminosity diagram. Star C is possibly somewhat undermassive for its observed luminosity. The fact that star D is invisible and has a larger value for the mass than has star C indicates that it may be a white dwarf. This possibility was first suggested in 1947 by van de Kamp.

This study was carried out during 1951 and 1952 at the Dearborn Observatory, Northwestern University, Evanston, Illinois, under the direction of Dr. K. Aa. Strand, Director of the observatory.

*Yale University Observatory,
New Haven, Conn.*

Green, Louis C. and Marjorie M. Mulder. **Correlation energy in the ground state of HeI.**

Wave functions of high accuracy are needed for the computation of atomic transition probabilities. It is generally recognized that configuration interaction can play an important role in the determination of both wave functions and energies for the various atomic states. With a view to examining the effects of configuration interaction in a simple case, use has been made of expansions of the three- and six-term expressions, given by Hylleraas, for the ground state wave function of HeI in series of Legendre functions of the cosine of the angle between the two radii vectores. The coefficients in these expansions are functions of r_1 and r_2 , the distances of the two electrons from the nucleus. The contributions of the various components to the total energy are presented. A discussion is given of the method of estimating the magnitude of the correlation, or configuration interaction, energy. Evidence is presented that the total correlation energy is at least $-0.129 R_H hc$ and may be even

more negative. Of this amount $-0.056 R_H hc$ is associated with the radial part of the correlation energy and $-0.073 R_H hc$ with the angular part.

1. L. C. Green et al., *A. J.* **57**, **11**, 1952.

*Strawbridge Observatory,
Haverford College,
Haverford, Pa.*

Hardie, Robert. A six-color photoelectric photometer.

A photoelectric photometer having a spectral range from 3500 to 10,000 Å is described. The cell used is a nineteen-stage multiplier with a silver-caesium-oxide cathode built by Professor A. Lallemand of the Observatoire de Paris. It has a good signal-to-noise ratio when cooled with dry ice and results to date indicate that useful measures may be made to about 11th magnitude in six colors, similar to those of Stebbins and Whitford, with the Perkins 69-inch reflector.

A preliminary color-temperature for the star CY Cyg, 8.8 vis. mag., has been derived. For this purpose only four colors were used since the violet and ultraviolet filters have leaks in the infra-red; these have effective wave lengths of approximately 8700, 7000, 5200, 4500 Å. The apparent color-temperature is $2380^\circ \pm 40^\circ$. If this star is reddened to the same degree as 55 Cyg (which is about $\frac{1}{2}^\circ$ from CY Cyg) and if its visual absolute magnitude is assumed to be around -4 , then the corrected color-temperature turns out to be 3200° ; if, however, it is reddened only to a degree based on the average for the surrounding region, the temperature is then 2950° .

*Perkins Observatory,
Delaware, Ohio.*

Heeschen, David S. Calculated line profiles for the 21-cm line of hydrogen.

The line profile of the 21-cm line of hydrogen is determined by the following parameters:

1. The density n , of neutral hydrogen atoms along the line of sight.
2. A parameter which characterizes the population of the energy levels of the hydrogen atom. If the hydrogen is in thermodynamic equilibrium this parameter will be the kinetic temperature T_e .
3. The turbulent velocity, c_0 , of the hydrogen clouds.
4. Galactic rotation.

Observations of the line then, may be expected to yield information about these quantities, if the

observations can be correctly interpreted. In order to determine how these quantities affect the shape of the line, theoretical profiles have been computed for several directions in the galaxy. We are concerned primarily with n and T_e , it will be assumed that $c_0 = 10$ km/sec and that the variation of rotational velocity with distance from the galactic center is that given by Oort.¹

The equation for the line profile is

$$\Delta T = T_e(1 - e^{-\tau_\nu}),$$

where ΔT is the observed intensity in the line, in temperature units. This equation was derived by Wild for a uniform medium not undergoing galactic rotation.² Here it applies more generally to a medium where there is galactic rotation providing the following assumptions, made in the derivation, hold:

1. Local thermodynamic equilibrium,
2. Constant temperature T_e ,
3. Negligible emission and absorption in the continuum.

The effect of deviations from the first two of these conditions is being investigated.

The optical depth τ_ν is

$$\tau_\nu = 25.8 \times 10^{-16} \int_0^l \frac{n}{T_e} f(\nu) ds,$$

where

$$f(\nu) = \frac{c}{c_0 \nu_0 \sqrt{\pi}} \exp. - \left(\frac{c}{c_0 \nu_0} [\nu - \nu_0 - \Delta\nu(s)] \right)^2.$$

$\Delta\nu(s)$ is the frequency shift due to the rotational velocity at the point s on the line of sight. For the calculations τ_ν was approximated by the summation

$$\tau_\nu = 25.8 \times 10^{-16} \frac{\Delta s}{T_e} \sum n f(\nu).$$

The summation was carried out over 200 parsec intervals along the line of sight. In making the calculations it was assumed that the gas extended to a distance of no more than 20,000 parsecs from the center, and that the thickness of the gas layer was 200 parsecs. An approximate correction was made for the effect of observing the line with an antenna having a beam width of 2° .

The direction of the center, where the line is not broadened by galactic rotation, presents the simplest case. Line contours have been computed for various values of N , assuming $T_e = 100^\circ$. Here N is the total number of atoms in a column, extending along the line of sight, having a base

area of one square centimeter. If the line is saturated the height ΔT is equal to the kinetic temperature of the gas, and the width of the line is determined by N . At a temperature of 100° the line becomes saturated for values of N greater than $10^{22}/\text{cm}^2$. At the other extreme, if the optical depth is small, ΔT at the center of the line is determined solely by N . In the intermediate case the height is determined by N/T_e as well as by T_e , and it becomes somewhat more difficult to determine N and T_e from an observed line.

The line observed by Muller and Oort, and by Purcell and Ewen, in the direction of the center is not saturated, and has a height of the order of 50° – 100° . Assuming $T_e = 100^\circ$ and $c_0 = 10$ km/sec, this gives an upper limit for N of about $10^{22}/\text{cm}^2$. If the hydrogen density were uniform and equal to $1/\text{cm}^3$ from the sun through the center to a corresponding distance on the other side, N would be about $5 \times 10^{22}/\text{cm}^2$. We might take this as an indication that the hydrogen density in the central region of the galaxy is somewhat lower than in the sun's neighborhood. This must be a very provisional conclusion however since neither T_e nor the hydrogen density around the sun are well determined.

In a direction 45° from the center the line is greatly broadened by galactic rotation, making it possible to "see" to great distances. Line profiles were computed for three values of uniform density. These contours reflect the assumed rotational velocity curve. There is a strong maximum at $\Delta\nu = -0.3$ mc/sec due to the region where the line of sight passes nearest to the center of the galaxy. In this region the galaxy is rotating almost like a solid disk so there is little change in radial velocity along the line of sight. If it is assumed that the central part of the galaxy is devoid of hydrogen this maximum disappears. The maximum at $\Delta\nu = +0.6$ mc/sec is due to the most distant part of the galaxy, where again the radial velocity changes slowly.

The line profile arising from a hypothetical spiral arm 15,000 parsecs from the sun, in the direction 45° from the center, was also computed. The spiral arm was arbitrarily taken to be 600 parsecs wide along the line of sight, with a density of $1/\text{cm}^3$. The density everywhere else along the line of sight was assumed to be $0.1/\text{cm}^3$. The contour shows two maxima—one due to the spiral arm, the other due again to the central portion of the galaxy.

Line profiles were also computed for directions 90° and 135° from the center.