effect resulting in a departure from Newtonian motion of 50 km in the radius.

The heliocentric radius r of Icarus as predicted by the theory of general relativity is

$$\frac{1}{r} = \frac{1}{p} \left[1 + e \cos \left(\theta - \theta_0 - \frac{\alpha}{p} \theta \right) \right] + \frac{\alpha}{p^2} \left[\left(1 + \frac{1}{2} e^2 \right) - \frac{1}{6} e^2 \cos 2(\theta - \theta_0) \right], \quad (1)$$

where p and e are the semilatus rectum and eccentricity of the osculating ellipse, α is three times the gravitational radius of the sun, and $\theta - \theta_0 - (\alpha/p)\theta$ is true anomaly in the osculating ellipse. The relativistic advance of perihelion is predicted from the rate α/p in the $e \cos [\theta - \theta_0 - (\alpha/p)\theta]$ term; the remaining terms represent a departure in radius from that predicted for Newtonian motion (cf. Smart, *Celestial Mechanics*, pp. 243-246). Evaluating Eq. (1) for Icarus near close approach: $p=0.3413$ a.u., $e=0.8266$, $\alpha=2.957 \times 10^{-8}$ a.u., $\cos 2(\theta - \theta_0)=0.270$, $r=1$ a.u.; the effect in radius is found to be

$$\Delta r = -49.8 \text{ km.} \quad (2)$$

Because Icarus passes within 7×10^6 km of earth in 1968, with heliocentric radius perpendicular to the line of sight, the angular displacement from the Newtonian position will be

$$\arctan(49.8 \text{ km} / 7 \times 10^6 \text{ km}) = 1''.4. \quad (3)$$

Simultaneous Shock Tube Measurements of Fe and Cr f values of Astronomical Interest. LEO GOLDBERG, MARTIN HUBER, W. H. PARKINSON, E. M. REEVES, AND F. L. TOBEY, *Harvard College Observatory*.—Measurements of relative f values of selected iron and chromium lines have been made in the wavelength range 3200 to 3800 Å. Line strengths were measured photographically by absorption through the region behind a reflected shock in a pressure-driven shock tube with a wide spectrograph slit. Temperatures were determined from the brightness and emissivity of the shocked gas. Low concentrations of iron and chromium were introduced together as carbonyls, premixed with the argon test gas. This was done to ensure the equal processing of both atoms and to reduce systematic errors in the ratios of oscillator strengths of the two elements. Populations of the absorbing levels were determined from the Saha-Boltzmann equation, the hydrodynamic equations and the charge neutrality condition.

The experimental uncertainties are 15% or better. The f value ratios obtained agree within a factor of 2 with ratios computed from literature f values adapted to a common scale (Corliss, C. H., and

Bozmann, W. R., *Natl. Bur. Stds. Monograph* 53, 1962, for Cr; Corliss, C. H., and Warner, B., *Astrophys. J. Suppl.* No. 83, 1964 for Fe).

The technique of simultaneous measurements of relative f values yields consistent oscillator strengths for two elements and provides data for an accurate relative abundance determination.

A Study of Broad Absorption Features in the Solar Spectrum. LEO GOLDBERG, GERALD NEWSOM, W. H. PARKINSON, AND E. M. REEVES, *Harvard College Observatory*.—The broad depressions (2.6 Å wide) in the solar spectrum at λ 6362 and 6343 have recently been identified (Mitchell and Mohler, *Astrophys. J.* 141, 1126, 1965) as the auto-ionizing transitions $3d4p \ ^3F^\circ - 3d4d \ ^3G$ in neutral calcium. A shock tube was used to determine the gf values of these lines and preliminary values have been derived. The McMath Solar Telescope at the Kitt Peak National Observatory was used to observe these lines and to search for other broad absorptions. At the center of the disk, the depressions for the 6362 and 6343 Å lines were $4.3 \pm 0.1\%$ and $2.8 \pm 0.2\%$, respectively, while near the limb ($\mu=0.2$) the percentage depression decreased by 17%. Spectra of cool, high-luminosity stars, kindly loaned by Mount Wilson and Palomar Observatories, also showed these auto-ionizing lines. Several other broad depressions which have been observed in the sun are discussed.

Review Paper: The Radio Characteristics of Radio Galaxies and Quasi-Stellar Sources. F. T. HADDOCK, *Radio Astronomy Observatory of the University of Michigan*.

An Upper Limit for the Diameter of Pluto. IAN HALLIDAY, ROBERT H. HARDIE, *Dominion Observatory*, OTTO G. FRANZ AND JOHN B. PRISER, *U. S. Naval Observatory*.—A possible occultation of a 15th magnitude star by the planet Pluto was predicted for the night of 28/29 April 1965 at a time suitable for observation from North America (Halliday, I., *Sky and Telescope* 29, 216, 1965). Numerous observatories cooperated in the attempt to determine the diameter of Pluto from the duration of the occultation. While no occultation was observed, a series of plates secured with the 61-in. astrometric reflector of the U. S. Naval Observatory at Flagstaff, in combination with the negative photoelectric results, permits an upper limit to be assigned to the diameter.

The photographic records show that Pluto passed south of the star at 5^h 12^m UT, 29 April, with a mini-