decide to which cosmological model our universe belongs.

Variability of the Optical and Radio Emission of Quasi-Stellar Sources. M. F. BARNOTHY AND J. M. BARNOTHY, *University of Illinois*.—The synchrotron emission and self-absorption mechanism suggested by Dent (*Science* **148**, 1458, 1965) and by Maltby and Moffett (*Science* **149**, 63, 1965) for the variable radio component of 3C273B requires for the injection of the relativistic electrons a source confined in a volume of 2 pc diameter, with an energy output comparable to that of the visible universe. We can avoid this unlikely energy requirement if we adopt the suggestion made by one of us (Barnothy, J. M., *Astron. J.* **70**, 666, 1965), namely that quasi-stellar sources are merely optical effects created by gravitational lenses acting upon nuclei of Seyfert galaxies. The variable component could then arise by two different mechanisms: (a) a supernova explodes in a distance less than 1 pc from the optical axis of the gravitational lens. Through the amplification, the brightness of the supernova would appear as having an absolute magnitude $M = -27$, increasing thus the brightness of 3C273B by $-1^m.4$. The electrons emitted by the supernova and trapped by its magnetic field of, say, $H = 10^{-2}$ G will produce a synchrotron radio emission which would increase the radio emission by about four flux units, provided that the energy output in the form of relativistic electrons is equal to the optical emission of the supernova. The optical brightness variation will follow the light curve of the supernova, while the radio emission will follow the time integral of the light curve; resulting in a phase difference between the intensity changes of the two emissions, as noted by Dent. (b) Violent events (velocities up to 3000 km/sec) which occur in the nuclei of Seyfert galaxies will cause within few years considerable changes in the magnetic field, electron density, and star distribution in the area surrounding the optical axis, where the brightness amplification can reach values up to 10^{10} . Should the optical axis thereby intercept a bright star or an area of high magnetic field and relativistic electron density, optical and radio emission variations with magnitudes as observed may result.

Variations in 3C345. J. FREDERICK BARTLETT, *California Institute of Technology*.—In the course of a study of radio source structure at the Owens Valley Radio Observatory, which extended from April 1962 to June 1964, six sets of observations were taken at a wavelength of 10.6 cm of the object 3C345, which has been identified with an optical counterpart displaying quasi-stellar properties (Sandage, A. B., and Wyndham, *Astrophys. J.* **141**, 328).

It has been possible to confirm the flux variation first discovered at 3.75 cm (Dent, *Science* **148**, 1458). Moreover, the total increase over the observed period was nearly 50%. Additional observations taken during 1965 indicate that the flux level has decreased since then and is now 20% above the 1962 value.

Restricted Problem of Three Bodies. JAMES H. BARTLETT (introduced by G. C. McVittie), *University of Alabama*.—The equations of motion of a sputnik in the gravitational field of two other bodies of finite mass have been integrated numerically, using a modified Runge-Kutta-Gill procedure. If the masses are m_1 and m_2 , and $\gamma = (m_1 - m_2) / (m_1 + m_2)$, K is the Jacobi constant and $T = K - \gamma^2$, and if E and F are the Thiele regularizing variables, then a periodic solution may be represented by a plot of F vs E for given values of T and γ . A continuous family of such solutions forms a surface in (T, E, F, γ) space, which may be termed an eigensurface and which is characteristic of a *class* in the terminology of Strömberg.

More than 9000 periodic solutions have been determined, and the evolution of the simple symmetric classes (α), (f), and (n) has been traced over the whole mass-ratio range $-1 \leq \gamma \leq 1$. The class (g - f) and the new symmetric classes (β), (δ), and (α - δ) have been studied over the range $-1 \leq \gamma \leq 0.93$. Asymptotic periodic orbits have been calculated as a function of mass ratio, and found to appear and disappear in pairs. Further, some new asymmetric classes have been discovered.

For a given mass ratio γ , and $E = 0$, the section of the eigensurface is a plot of T vs F and may consist of more than one curve. As γ varies, these curves may move toward each other, touch, and split into two other curves which then move apart.

When the eigensurface touches the zero-velocity surface, a change of symmetry (reversal of velocity) occurs, as from g to f and from α to δ .

The g class at $\gamma = -1$ consists of at least two branches which cross, one with eccentricity not zero and the other with eccentricity zero. As γ increases, these two branches split apart sideways. Since the curves at $\gamma = -1$ do not appear to possess any single quantity which is invariant, it is unlikely that the curves for $\gamma \neq -1$ have an invariant, either.

New Observations of Solar Chromospheric Spicules. JACQUES M. BECKERS, *Sacramento Peak Observatory*, ROBERT W. NOYES, *Smithsonian Astrophysical Observatory*, AND JAY M. PASACHOFF, *Harvard College Observatory*.—We observed the spectra of spicules on the solar limb simultaneously at two heights in the quiescent chromosphere with the

16-in. coronagraph and the 12-m Littrow spectrograph at the Sacramento Peak Observatory during the summer of 1965. Time sequences of simultaneous observations were obtained, using the following combinations of lines: K , H , $H\epsilon$, and D_3 ; H , $H\epsilon$, D_3 , and the O I infrared triplet; H , $H\epsilon$, D_3 , and the Ca II infrared triplet; and $H\beta$ and $H\alpha$. Time intervals between exposures ranged from 5 to 30 sec, and the height separation was 2000 km. Our preliminary conclusions follow.

(a) A strong correlation exists between the intensities of the spectra of spicules in $H\epsilon$ and D_3 , while spectra in H and $H\epsilon$ show less correlation. The rare earth line between H and $H\epsilon$ shows no brightness or velocity structure. This suggests that it is non-spicular in origin.

(b) We see the line-of-sight velocities of some spicules reverse in direction. This suggests that the apparent rising and subsequent falling seen in $H\alpha$ on the limb may represent actual mass motions. Further, most of the spicules with large line-of-sight velocities seem to be moving faster at the higher than at the lower levels.

(c) The profiles of the H and K lines are indeed very broad with respect to the $H\alpha$ line, in agreement with Athay. It is unlikely that these large widths are caused by overlapping spicules.

(d) Many spicular spectra are tilted with respect to the direction of the dispersion. We believe this to be a real effect, caused by differential motions across the spicule.

(e) The H and K lines are strongly self-reversed at low levels. We believe the self-reversal to be non-spicular in origin because it does not share the Doppler shifts of spicules.

Microphotometry and detailed reduction of the data are underway.

Relative Transition Probabilities for Prominent Ni I and Ni II Lines in the Near Ultraviolet. G. D. BELL (present address: *Harvey Mudd College*), D. R. PAQUETTE, AND W. L. WIESE, *National Bureau of Standards*.—Relative transition probabilities of 16 Ni I lines and 53 Ni II lines in the wavelength range from 2000–3600 Å have been measured with a wall-stabilized arc. The arc was operated at 10 Å in argon with a small admixture (0.01%) of nickel-carbonyl. The spectrum was photoelectrically observed along the arc axis through the hollow electrodes. The relative intensity calibrations were performed by utilizing calibrated tungsten strip lamps or the continuous emission of a hydrogen arc operated at known plasma conditions. The axis temperature of the argon nickel-carbonyl arc was determined from intensity measurements of argon lines of known transition probabilities and the application of the arc plasma equations. For most of the relative f values

the experimental and theoretical uncertainties are 8% or better, but for a few weak lines the uncertainties go as high as 30%. Comparisons with other experimental and theoretical results are undertaken and fair agreement is obtained. The relative f values for both the Ni I and Ni II lines have been put on an absolute scale by using the absolute oscillator strengths of a few prominent Ni I lines recently reported by Lawrence, Link, and King (*Astrophys. J.* **141**, 293, 1965).

This work was supported in part by the Advanced Research Projects Agency.

Abundance and Temperature of CO_2 in the Martian Atmosphere. MICHAEL J. S. BELTON AND DONALD M. HUNTEN, *Kitt Peak National Observatory*.—Spectrophotometric observations of the R branch of the weak $\nu_1+2\nu_2+3\nu_3$ band of CO_2 at 1.05 μ in the spectrum of Mars yield an atmospheric abundance of 69 ± 26 (atm·m)_{STP}. Taken together with the results of Gray's (1965) analysis of the strong bands of CO_2 at 2.0 μ , this abundance indicates a surface pressure in the range of 3–13 mbar. Individual lines in the branch have been resolved up to $J=28$ and their intensity distribution indicates a rotational temperature of 194 °K. The head region alone yields a somewhat higher temperature of 210 °K. The observations were also analyzed with the help of a polytropic model atmosphere. The most satisfactory fit to the data was found for a mean surface temperature of 270 °K over the illuminated disk and a lapse rate of 5 °K/km.

A brief discussion of the compatibility of the present observations with others that are available concludes the paper.

Wolf-Rayet Binary HD 197406. KATHERINE BRACHER, *University of Southern California*.—HD 197406 is a rather faint single-line spectroscopic binary of spectral class WN7, showing fairly narrow emission lines of He II, He I, N IV, N III, and Si IV. Spectrograms obtained at Kitt Peak National Observatory in 1964, together with plates taken at Mount Wilson in 1946–49 and remeasured for this investigation, yield a period of 4.3207 days. The resulting velocity curves suggest a zero eccentricity, and rather small values of K . These give a mass function of 0.07 $\odot$, and a semimajor axis $a_w \sin i = 3.2 \times 10^6$ km. Photometric observations at the Goethe Link Observatory show a slight diminution of light (0^m.06) during the half of the cycle when the W star is in front. Assumptions concerning the inclination, based on this eclipse, lead to a suggested mass of 5–7 $\odot$ for the WN7 star, and an absolute magnitude of –1 to –2.