mento Peak Observatory. This unit permits digitizing with three-digit accuracy up to a rate of 3.75 points per second by alternating between two IBM 526 summary punches. A system for going to 20 points per second has been planned. Automatic recording of the output of a high-speed photon counter has also been developed.

Further Evidence for Gas Streams in Barred Spirals: NGC 4027 and NGC 7741. G. DE VAUCOULEURS AND A. DE VAUCOULEURS, *McDonald Observatory*.—Evidence has been presented (*Astron. J.* **67**, 113, 270, 1962) of large-scale departures from circular motions in NGC 4631, a late-type barred spiral of the Magellanic-type seen edgewise. In order to place the interpretation of the rotation curve and the reality of gas streaming in bars beyond doubt it was necessary to find typical SB(s)d and SB(s)m systems meeting the following conditions: (a) the inclination angle is such that the spiral structure is immediately in evidence ($i < 60^\circ$), but not so small that departures from circular motion will have negligible line-of-sight components, and (b) the bar is in the plane of vision, i.e., is along the minor axis of the projected image, so that the rotational velocity will have no component on the line of sight and any line shift observed will directly reflect departures from circular motions.

Two systems meeting these rather strict requirements, NGC 4027 and 7741, have been found; they were observed recently with the prime-focus spectrograph of the 82-inch telescope at McDonald Observatory. Measurements of the $\lambda 6563$ ($H\alpha$) and $\lambda 6584$ [$N\text{II}$] emission lines in spectrograms taken with the slit placed along the bars are presented; in both galaxies the lines are conspicuously inclined and the geometric relationships are such that the tilt corresponds to stream velocities of the order of ± 50 to 100 km/sec directed along the bar and away from the center. This direct evidence supports the results previously derived from the analysis of NGC 4631.

Application of Nonlocal Mixing Length Theory to Stellar Structure Calculations. D. EZER, R. F. STEIN, AND A. G. W. CAMERON, *Institute for Space Studies*.—A new nonlocal mixing length theory has been used in calculations of the structure of the sun in its early contraction phases. This theory, due to E. Spiegel, differs from that formulated by Bohm-Vitense only through removal of the assumption that the mixing length is an intrinsically small and local quantity. The new theory uses an integral expression for the convection flux which is related to the differential Bohm-Vitense expression in much the same fashion that integral and differential expressions for the radiative flux are used for small

and large optical depths. In the new theory, a convection source function exists wherever the temperature gradient is superadiabatic; such source functions can give rise to convective motions which overshoot far into regions where the temperature gradient is subadiabatic. We have compared the two theories by calculating atmospheres for a fully-convective contracting solar model of $20 R_\odot$. Some differences were obtained for the stellar structure in the transition layer, but these were not sufficiently great to justify the extra computing time required by the Spiegel method in most applications of convection theory to stellar structure calculations. However, the convective penetration into stable layers may cause mixing of material far away from the convective zone. This may have important effects on the availability of nuclear fuels during stellar evolution, since the convective mixing times are many orders of magnitude less than evolutionary times.

Production of Low-Energy Cosmic Rays by Collisions of High-Energy Cosmic Rays with Interstellar Gas. M. FERENTZ AND S. N. MILFORD, *Grumman Aircraft Engineering Corporation*.—The production rate of protons of energy less than 1 BeV in interstellar space is calculated from empirical cross sections for proton-proton elastic and inelastic collisions in the kinetic energy range 1 to 30 BeV.

Representing the cosmic ray intensity by a simple fit to the observed spectrum in the absence of solar activity the production spectrum is found to decrease steadily from zero energy to a value one-tenth as great at 500 MeV. The integrated production rate of 0–500 MeV protons is $\sim 10^{-26} \text{ cm}^{-3} \text{ sec}^{-1}$ from elastic collisions, and the contribution from inelastic collisions is estimated to be of lower order.

The production spectrum is combined with the slowing lifetimes of protons in the interstellar gas (Meskys and Milford, *Bull. Am. Phys. Soc.* **8**, 305, 1963) to give the density of these 0–500 MeV protons as $\sim 10^{-11} \text{ cm}^{-3}$ with an intensity of $\sim 10^{-1} \text{ cm}^{-2} \text{ sec}^{-1}$. Recently Hayakawa, Nishimura, and Takayanagi (*Publ. Astron. Soc. Japan* **13**, 184, 1961) have suggested that low-energy cosmic rays contribute appreciably to the heating of interstellar gas clouds, with an assumed low-energy cosmic ray intensity of order $100 \text{ cm}^{-2} \text{ sec}^{-1}$. From the above calculations it may be seen that high-energy collisions can not supply any significant fraction of such a hypothesized high intensity.

Future measurements of low-energy interstellar cosmic rays will indicate what fraction of these can be attributed to the collision mechanism discussed above, and what fraction must be due to other mechanisms, such as stellar injection and interstellar magnetic field acceleration.