resulting from these events. As a means of monitoring the general functioning of the instrument, charged particles traversing the anticoincidence shell are also continuously sampled. All these data are telemetered to the ground receiving station along with those from the other satellite sub-systems. The entire TIFR experiment weighs about 22 kg and consumes about 1.6 watt power.

The scientists associated with the TIFR experiment are Drs. M. V. K. Apparao, S. V. Damle, R. R. Daniel, G. S. Gokhale, G. Joseph and P. J. Lavakare.

R. R. Daniel

Tata Institute of Fundamental Research
Bombay 400 005

REDETERMINATION OF THE HUBBLE CONSTANT AND THE DECELERATION PARAMETER

Astronomers appeal to observational data furnished by distant galaxies to study the structure and evolution of the universe. In the nineteen twenties, Hubble discovered, from the measurements of the spectral features, that the velocity of recession of distant galaxies is proportional to their distances from us. This proportionality constant which has the unit of inverse time is the Hubble constant, H_0. Since the time when Hubble made the measurements, the value of this constant has been successively revised by more refined observatoins. In 1956, the largest redshifts measured were around $z = 0.2$ and on this basis Humason, Mayall and Sandage (*A. J.*, **61,** 97, 1956) gave a value of $H_0 = 180$ km sec^{-1}Mpc^{-1}. In the nineteen years that have since elapsed, Sandage and his collaborators have systematically revised the measurement of the Hubble constant. In 1968, Sandage (*Observatory*, **88,** 91, 1968) adopted a value of 75 km sec^{-1} Mpc^{-1} for H_0, while in 1974, based on the observations of nearby galaxies, the local value of the Hubble constant was given as 56.9 $\pm$ 3.4 km sec^{-1} Mpc^{-1} (cf. Sandage and Tammann, *Ap. J*, **194,** 559, 1974).

Recently, Sandage and Tammann (preprint) have reestimated the value of H_0 by measuring the redshifts of a sample of remote spiral galaxies in the apparent magnitude range $13.5 \lesssim m \lesssim 15.8$. This was done largely to remove any possible disturbances of the local velocity field by " the inhomogeneous clumping of nearby galaxies in the Ursa Major, Virgo, Coma region ". The principal conclusion of this study is that the *global* value of the Hubble constant is 55 $\pm$ 5 km sec^{-1} Mpc^{-1}, not altogether different from the corresponding estimate for H_0 obtained by using the local sample of galaxies.

In standard cosmological models, to a sufficient accuracy, H_0^{-1} represents the time since the expansion began; based on the latest estimate of H_0, this time is $17.7^{+1.8}_{-1.5} \times 10^9$ years, which is an order of magnitude larger than the time scale given by Hubble in 1932. But to find the actual age of the universe, T_0, one requires a knowledge of the deceleration parameter, q_0, which essentially embodies the rate of slowing down of the universal expansion, because of the attraction exerted by the total mass-energy present in the universe. In the past, the value of q_0 has been determined by using the observed redshift-magnitude relationship for galaxies with large redshifts. But Sandage and Tammann now adopt a somewhat different approach to determine q_0. Employing the standard formulae in Friedmann models of the universe, they write the following relationship:

$$T_0 = f(q_0)\, H_0^{-1},$$

where $f(q_0)$ is some known decreasing function of the deceleration parameter. In order to solve this equation for q_0, the value of H_0 is inserted from the current estimate of the Hubble constant and the age of the universe is estimated by appealing to various data concerning the age of globular clusters, time-scales for the formation of galaxies and the apparent cut-off in QSO redshifts at $z \simeq 4$. Thus, for globular clusters, taking a lower limit for their age as $14 \pm 1 \times 10^9$ years, the upper limit of the deceleration parameter is found to be:

$$q_0\,(H_0 = 55) = 0.17^{-0.10}_{+0.26},$$

$$q_0\,(H_0 = 50) = 0.35^{-0.18}_{+0.40}.$$

However, if the time-scale for galaxy formation, after the birth of the universe, is taken into account and is adopted to be $\simeq 10^9$ years, then $T_0 \simeq 15 \pm 1 \times 10^9$ years gives the more realistic values:

$$q_0\,(H_0 = 55) = 0.10^{-0.08}_{+0.16},$$

$$q_0\,(H_0 = 50) = 0.20^{-0.12}_{+0.26}.$$

If the cut-off in quasar redshifts at $z \simeq 4$ is taken to be real and attributed to the epoch of the first galaxy formation, then

$$q_0\,(H_0 = 50) = 0.03^{-0.03}_{+0.07}.$$

It is clear from the successive values of q_0 obtained over the years that improved observations have led to a steady decrease in the value of q_0. Might one speculate that at a future date more refined observations would produce even negative values of q_0 !

S. M. Chitre

Tata Institute of Fundamental Research
Bombay 400 005

LUNAR OCCULTATION OF X-RAY SOURCE IN CRAB NEBULA

During mid-1974 and early 1975, many attempts were made to establish the size and possible structure of X-ray source in the Crab nebula, during its lunar occultation. First such experiment was conducted by NRL in 1964 during its previous occultation. Later on, modulation collimator technique was used to establish the size of the X-ray source,