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A new cosmological test

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<http://www.bdim.eu/item?id=RLINA_1975_8_58_3_405_0>

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Cosmologia. — *A new cosmological test.* Nota di GIULIANO ROMANO, presentata (*) dal Socio L. ROSINO.

RIASSUNTO. — Si propone un nuovo test dei modelli cosmologici basato su pure osservazioni fotometriche.

In a recent paper, Borbon, Ciatti and Rosino (1973) have shown that the supernovae type I form a homogeneous group of distance indicators. The similarity of the light curves and the small dispersion of the points over the mean light curve suggest the possibility of using these objects for a cosmological test.

It is well known that in a uniform world model, usually expressed by the Robertson-Walker metric, if R is the value of the cosmic scale factor at time t when light is emitted from P, and R_0 is the value when it reaches us, at present time t_0, a light signal, emitted from P during the world time interval Δt and received during the interval Δt_0, satisfies the relation:

$$\frac{R_0}{R} = \frac{\Delta t_0}{\Delta t} = a . \tag{1}$$

If Δt and Δt_0 are the periods of an electromagnetic wave, the expression relating the scale factor with the red-shift z of the point P is:

$$1 + z = \frac{R_0}{R} .$$

A proof that the red-shift is connected with the cosmic expansion could be obtained if it would be possible to relate, for example, the duration of the maximum of a distant supernova with that of a nearest one. Other time intervals, like the numbers of days to fall of one or two magnitudes from maximum or the rate of decline could also be useful.

Let us assume that a supernova of type I at maximum is about three magnitudes fainter than the parent galaxy. Since according to Sandage (1968) the relation between the correct blue magnitudes of first ranked galaxies in a cluster and their red-shift is:

$$m_B = 5 \log cz - 6.06$$

we can see that for a ratio $\boldsymbol{a} = 1.1$, the blue magnitude of SN I at maximum is about 19^m and, for a correct study of its evolution it will be necessary to

(*) Nella seduta dell'8 marzo 1975.

follow the supernova to 22^m. The same values for $\boldsymbol{a} = 1.5$ are $\sim 23^m$ and $\sim 26^m$ and for $\boldsymbol{a} = 2$ respectively $\sim 24^m$ and $\sim 27^m$.

These estimates indicate that only when the photometric measures are extended at very faint magnitudes this method will be useful.

Fig. 1 shows the light curves of a typical supernova for two different values of $\boldsymbol{a}$. The mean light curve is derived from the paper of Barbon *et al.* (1973).

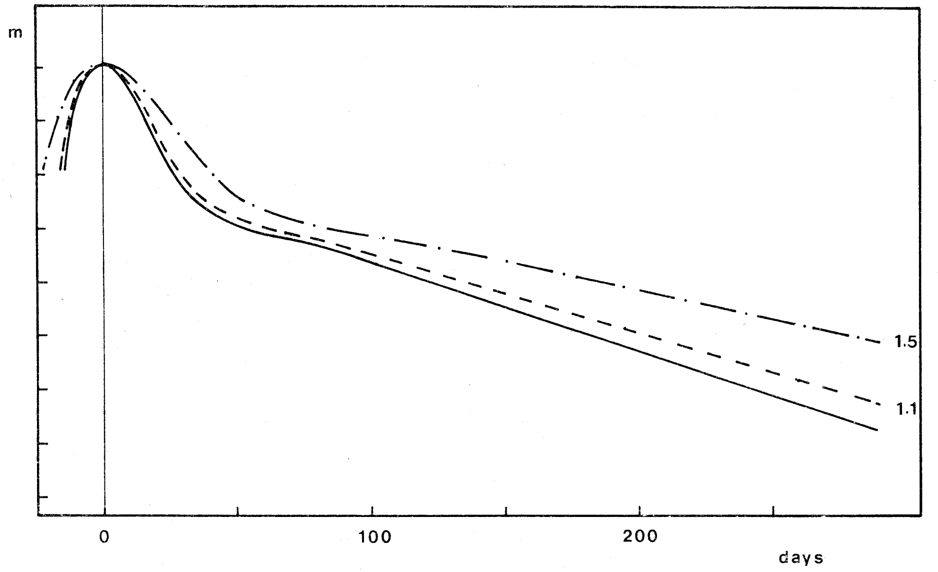

Fig. 1.

Future studies of very distant SN–I will offer also the possibility to discriminate among world models. In fact if the precedent test confirms the cosmic expansion, then the acceleration parameter q_0 can be determined from the ratio $\boldsymbol{a}$ and the bolometric magnitudes m_b of SN–I at maximum.

From the definition of $\boldsymbol{a}$, given in equation (1), the Mattig magnitude–red shift relation can be reduced to:

$$m_b = 5 \log q_0^{-2} \left[q_0 (a - 1) + (q_0 - 1) \sqrt{1 - 2 q_0 (a - 1)} \right] + \text{const.}$$

which shows that this cosmological test implies only photometric measures which can be extended to very faint magnitudes.

For practical applications of this relation it would be interesting to extend the observations in the following directions:

1) Detailed studies of supernovae spectra in regions beyond the optical range for the determination of the bolometric magnitude of these stars at maximum.

2) Survey of supernovae in distant clusters of galaxies with large telescopes.

3) Use of large space telescopes which may reach magnitude 29 (NASA SP–213).

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