3C 273: A STAR-LIKE OBJECT WITH LARGE RED-SHIFT

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THE only objects seen on a 200-in. plate near the positions of the components of the radio source *3C* 273 reported by Hazard, Mackey and Shimmins in the preceding article are a star of about thirteenth magnitude and a faint wisp or jet. The jet has a width of 1″–2″ and extends away from the star in position angle 43°. It is not visible within 11″ from the star and ends abruptly at 20″ from the star. The position of the star, kindly furnished by Dr. T. A. Matthews, is R.A. 12h 26m 33·35s ± 0·04s, Decl. + 2° 19′ 42·0″ ± 0·5″ (1950), or 1″ east of component *B* of the radio source. The end of the jet is 1″ east of component *A*. The close correlation between the radio structure and the star with the jet is suggestive and intriguing.

Spectra of the star were taken with the prime-focus spectrograph at the 200-in. telescope with dispersions of 400 and 190 Å per mm. They show a number of broad emission features on a rather blue continuum. The most prominent features, which have widths around 50 Å, are, in order of strength, at 5632, 3239, 5792, 5032 Å. These and other weaker emission bands are listed in the first column of Table 1. For three faint bands with widths of 100–200 Å the total range of wave-length is indicated.

The only explanation found for the spectrum involves a considerable red-shift. A red-shift $\Delta\lambda/\lambda_0$ of 0·158 allows identification of four emission bands as Balmer lines, as indicated in Table 1. Their relative strengths are in agreement with this explanation. Other identifications based on the above red-shift involve the Mg II lines around 2798 Å, thus far only found in emission in the solar chromosphere, and a forbidden line of [O III] at 5007 Å. On this basis another [O III] line is expected at 4959 Å with a strength one-third of that of the line at 5007 Å. Its detectability in the spectrum would be marginal. A weak emission band suspected at 5705 Å, or 4927 Å reduced for red-shift, does not fit the wave-length. No explanation is offered for the three very wide emission bands.

It thus appears that six emission bands with widths around 50 Å can be explained with a red-shift of 0·158. The differences between the observed and the expected wave-lengths amount to 6 Å at the most and can be entirely understood in terms of the uncertainty of the measured wave-lengths. The present explanation is supported by observations of the infra-red spectrum communicated by Oke in a following article, and by the spectrum of another star-like object associated with the radio source *3C* 48 discussed by Greenstein and Matthews in another communication.

Table 1. Wave-lengths and Identifications

λ	$\lambda/1{\cdot}158$	λ_0	
3239	2797	2798	Mg II
4595	3968	3970	$H\epsilon$
4753	4104	4102	$H\delta$
5032	4345	4340	$H\gamma$
5200–5415	4490–4675		
5632	4864	4861	$H\beta$
5792	5002	5007	[O III]
6005–6190	5186–5345		
6400–6510	5527–5622		

The unprecedented identification of the spectrum of an apparently stellar object in terms of a large red-shift suggests either of the two following explanations.

(1) The stellar object is a star with a large gravitational red-shift. Its radius would then be of the order of 10 km. Preliminary considerations show that it would be extremely difficult, if not impossible, to account for the occurrence of permitted lines and a forbidden line with the same red-shift, and with widths of only 1 or 2 per cent of the wave-length.

(2) The stellar object is the nuclear region of a galaxy with a cosmological red-shift of 0·158, corresponding to an apparent velocity of 47,400 km/sec. The distance would be around 500 megaparsecs, and the diameter of the nuclear region would have to be less than 1 kiloparsec. This nuclear region would be about 100 times brighter optically than the luminous galaxies which have been identified with radio sources thus far. If the optical jet and component *A* of the radio source are associated with the galaxy, they would be at a distance of 50 kiloparsecs, implying a time-scale in excess of 10^5 years. The total energy radiated in the optical range at constant luminosity would be of the order of 10^{59} ergs.

Only the detection of an irrefutable proper motion or parallax would definitively establish *3C* 273 as an object within our Galaxy. At the present time, however, the explanation in terms of an extragalactic origin seems most direct and least objectionable.

I thank Dr. T. A. Matthews, who directed my attention to the radio source, and Drs. Greenstein and Oke for valuable discussions.

ABSOLUTE ENERGY DISTRIBUTION IN THE OPTICAL SPECTRUM OF 3C 273

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THE radio source *3C* 273 has recently been identified with a thirteenth magnitude star-like object. The details are given by M. Schmidt in the preceding communication. Since *3C* 273 is relatively bright, photoelectric spectrophotometric observations were made with the 100-in. telescope at Mount Wilson to determine the absolute distribution of energy in the optical region of the spectrum; such observations are useful for determining if synchrotron radiation is present. In the wave-length region between 3300 Å and 6000 Å measurements were made in 16 selected 50-Å bands. Continuous spectral scans with a resolution of 50 Å were also made. The measurements were placed on an absolute-energy system by also observing standard stars whose absolute energy distributions were known[1]. The accuracy of the 16 selected points is approximately 2 per cent. The strong emission features found by Schmidt were readily detected; other very faint features not apparent on Schmidt's spectra may be present.

The source *3C* 273 is considerably bluer than the other known star-like objects *3C* 48, *3C* 196, and *3C* 286 which have been studied in detail[2]. The absolute energy distribution of the apparent continuum can be accurately represented by the equation:

$$F_\nu \propto \nu^{+0\cdot28}$$

where F_ν is the flux per unit frequency interval and ν is the frequency. The apparent visual magnitude of *3C* 273 is + 12·6, which corresponds to an absolute flux at the Earth of $3{\cdot}5 \times 10^{-28}$ W m^{-2} (c/s)$^{-1}$ at 5600 Å. At