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LINE INTENSITIES IN NGC 7027

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ABSTRACT

New photographic observations of NGC 7027 confirm Miller's finding that earlier spectrophotometry of NGC 7027 is afflicted with strong systematic errors.

I. INTRODUCTION

For the past 15 years the spectrum of NGC 7027 has been presented as an outstanding anomaly. The observations of Aller, Bowen, and Minkowski (1955) and Aller, Bowen, and Wilson (1963) (hereafter referred to as ABM and ABW, respectively) show that the high-order lines of various series of hydrogen and helium are much too bright compared with the stronger lines such as Hβ; variations from theory of up to a factor of 6 were noted (see also Kaler 1966).

Seaton (1960) was the first to suggest, on theoretical grounds, that the relative intensities of the faint lines were systematically overestimated. Kaler (1966) defended the observations by pointing out the consistency of the deviations of observation from theory among the series of hydrogen and helium which are in different parts of the spectrum and generally have quite different intensities.

Miller (1971) has recently completed a photoelectric study of the high-order Balmer lines and has demonstrated that they show a rough agreement with theory and that the earlier observations named above are indeed strongly affected by systematic error.

In this Note we report on a photographic study of the spectrum of NGC 7027 which confirms Miller's (1971) results, and we present a preliminary set of line intensities which shows very little systematic error over a wide range of intensity. A detailed analysis of the spectrum of NGC 7027 is now in progress.

II. THE OBSERVATIONS

We present the results of one plate of the blue spectrum of NGC 7027 taken 1970 June 12, with 4 hours exposure on a IIa-O emulsion at Mount Wilson. The data were reduced in the usual manner to outside the atmosphere with the aid of a calibration wedge and a plate of θ Crt. Proper account was taken of the variation of the characteristic curve with wavelength.

The results are presented in Table 1. The columns give, in order, wavelength, identification, and relative intensity (called I_n) on an arbitrary scale. The stronger lines such as Hβ were too strong to be measured. Let the intensities of ABM, ABW, and Miller (1970) be called I_0. The quantity I_0 then includes both photographically ($I_0^{\rm ptg}$) and photoelectrically ($I_0^{\rm pep}$) measured intensities. We present a comparison between I_n and I_0 in Figure 1, where I_0/I_n is plotted against I_0. The ratios $I_0^{\rm ptg}/I_n$ are presented as circles,

TABLE 1

OBSERVED INTENSITIES FOR NGC 7027

λ(Å)	Identification	I_n	λ(Å)	Identification	I_n
3203.....	He II	7.75	3835.....	H9	9.60
3312.....	O III	7.05	4026.....	He I	4.31
3341.....	O III	11.6	4069.....	[S II]	11.5
3346.....	[Ne V]	33.5	4076.....	[S II]	4.54
3429.....	O III	3.28	4097.....	N III	3.57
3444.....	O III	21.4	4103.....	N III	1.77
3676.....	H22	0.52	4200.....	He II	2.30
3679.....	H21	0.43	4267.....	C II	1.09
3683.....	H20	1.15	4339.....	He II	0.76
3687.....	H19	0.72	4387.....	He I	1.19
3691.....	H18	1.14	4471.....	He I	5.74
3697.....	H17	0.81	4541.....	He II	3.75
3703.....	H16	1.45	4571.....	Mg I	2.05
3712.....	H15	1.47	4634.....	N III	3.49
3722.....	H14, [S III]	5.61	4641.....	N III	7.32
3729.....	[O II]	10.5	4647.....	C III	1.51
3734.....	H13	3.37	4658.....	C IV	3.26
3750.....	H12	3.90	4686.....	He II	2.41
3755.....	O III	0.58	4711.....	[Ar IV]	5.50
3760.....	O III	6.90	4724.....	[Ne IV]	2.25
3771.....	H11	5.48	4726.....	[Ne II]	1.88
3797.....	H10	6.72	4740.....	[Ar IV]	14.8
3820.....	He I	1.09			

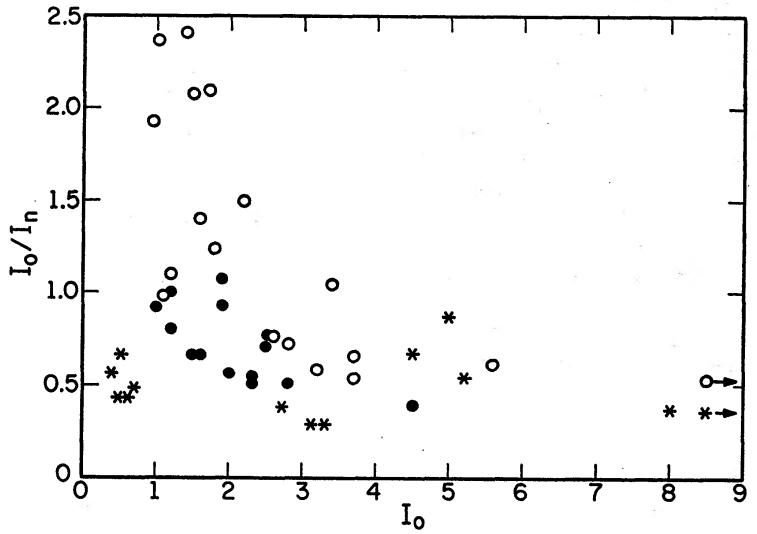

FIG. 1.—I_0/I_n plotted against I_0. The open and closed circles denote I_0^{ptg}/I_n for $\lambda < 4000$ Å and $\lambda > 4000$ Å respectively. *Asterisks*, I_0^{pep}/I_n; *arrows*, points for which $I_0 > 8$.

I_0^{pep}/I_n are shown as asterisks. The I_0^{ptg}/I_n are further divided: open circles denote points for $\lambda < 4000$ Å and closed circles for $\lambda > 4000$ Å. All I_0^{ptg} intensities are from ABW except for the few points where $\lambda > 4720$ Å.

Figure 1 shows the severe systematic error present in I_0^{ptg}; the faint lines are progressively overestimated. The relation is complicated by a wavelength effect; the error

becomes more severe as we go to shorter wavelengths. The fact that I_0^{pep}/I_n shows no recognizable systematic error in intensity (or in wavelength) over a very wide range indicates that the I_0^n are trustworthy, except for random error due to there only being one observation per line. The fact that I_0^{pep}/I_n from both Miller's data and the ABW data agree on the average strongly supports Miller's observations.

If we allow for some scatter, the ratios I_0^{pep}/I_n and the lower envelope to the I_0^{ptg}/I_n points indicate that the I_n presented in Table 1 should be multiplied by a factor of $\sim$0.55 to place them on a scale of I_n (Hβ) = 100.

In conclusion, we agree with Miller that the old photographically determined spectral intensities of NGC 7027 have been systematically overestimated. The reasons for this are unclear.

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