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THE PHOTOMETRIC RANGE OF EX LUPI

EX Lupi is the prototype star of the class of eruptive pre-main sequence variables called EXors. Although its declination (–40°) made it a difficult object for northern observers in the past, that problem has been alleviated in recent years, and there is much information on the star that has been collected from southern sites. However, no recent maxima have been reported, and so there is interest in upgrading the photometric history of EX Lupi for those earlier times when it was active.

McLaughlin (1946) published a summary of his investigation of the star's brightness on Harvard plates obtained between about 1893 and 1941. During most of this time EX Lup remained near minimum light, but on 5 occasions rose approximately 2 magnitudes in brightness to "nova-like maxima". These were spaced at intervals of 4 to 13 years. The photographic magnitudes of EX Lup were referred to a sequence of nearby stars whose identifications and adopted magnitudes are tabulated by McLaughlin.

An extensive series of visual estimates made by A.F. Jones between 1954 and 1956 were published by Bateson and Jones (1957). The most notable event during this time was a bright maximum in late 1955, followed by a weaker secondary brightening; the entire episode lasted about 2 years. (The Jones–Bateson observations are shown as a light curve in Fig. 14, Herbig 1977.) These visual observations were based on magnitudes estimated by Bateson for a set of nearby stars, most of them common to the sequence of McLaughlin.

The purpose of this note is to place these two sets of observations of EX Lup on a modern photometric system so that the range and behavior of EX Lup can be properly compared to those of other EXors.

Modern BV magnitudes were measured for the comparison stars of Bateson and Jones on CCD frames obtained on 15 September 1989 by one of us (N.S.) with the 0.9-m telescope of the Cerro Tololo Inter-American Observatory. The photometric solution was based on 26 of the E-region standards published by Graham (1982) and by Menzies, Banfield and Lang (1980); the scatter about the fit was 0.02 mag. in both B and V, but the magnitudes of the very brightest stars could be in error by as much as 0.04 mag. on account of shutter errors. The results are given in Table 1, where the stars are identified by the letter designations of McLaughlin (1946) or Bateson and Jones (1957).

Table 1
Magnitudes of Comparison Stars for EX Lupi

Star	B	V	B–V	Ptg.mag.	Vis.mag.
W	8.21	8.05	+0.16	—	8.4
X	8.56	7.94	0.62	—	8.9
Y	9.56	9.01	0.55	—	9.8
a	10.31	10.02	0.29	10.9	10.6
c	10.95	10.30	0.65	11.4	11.3
d	10.70	10.14	0.56	11.4	11.5
b	10.66	9.95	0.71	11.4	11.7
f	11.14	9.81	1.33	12.3	12.2
e	11.80	11.26	0.54	12.2	12.4
g	12.06	11.35	0.71	12.4	12.6
i	12.26	11.48	0.78	12.8	13.0
k	12.67	11.69	0.98	13.1	13.3
u	12.35	10.44	1.91	—	13.5
l	13.23	12.43	0.80	13.3	13.8
m	—	—	—	14.1	—
n	—	—	—	14.2	—
EX Lup	12.60	11.89	0.71		

The regression of B on McLaughlin's "ptg.mag." is acceptably linear:

$$B = 1.1678\ (pg) - 2.504 \qquad (1)$$

If it is used to convert McLaughlin's range for EX Lup, 11.4–13.9, in B that range becomes 10.8–13.7, the minimum being an extrapolation of 0.5 mag. beyond the faintest star measured in Table 1. Similarly,

$$V = 0.8106\ (vis) + 1.027 \qquad (2)$$

so that the Bateson–Jones range of 8.7–14.0 becomes 8.1–12.4 in V. The star *f* has been omitted in calculating both the above relationships; it seems to be about 1 mag. brighter in both B and V than one would have expected from the photographic and visual estimates.

These corrected ranges indicate that the B–V color of EX Lup at minimum light is about +1.3. This is not unreasonable: observations by Bastian and Mundt (1979) and by Mundt and Bastian (1980) on 5 nights in 1977 and 1979 gave a mean B–V of +1.11 at a mean B of 14.31. However, their mean V (13.20) is fainter than the corrected Bateson–Jones minimum magnitude of 12.4, and their mean photoelectric B is fainter than than McLaughlin's corrected minimum of 13.7.

Most intrinsic variables become bluer as they brighten, and indeed the single spectroscopic observation of EX Lup when bright (Herbig 1950) shows that the star became much hotter. Therefore a value of B–V = +2.8 for EX Lup at maximum light, from the corrected ranges, is not reasonable at all. The explanation must be that the 1955–56 maximum observed by Bateson and

Jones was 2–3 magnitudes brighter than any of the brightness peaks reported by McLaughlin. A discrepancy in this sense is understandable since the visual coverage of EX Lup at the 1955 maximum was much more complete than was possible for the Harvard plate series: the observations by Jones were often spaced one or several days apart, while gaps of several hundred days are apparent in McLaughlin's light curve. For that reason a V range of 8.1–13.2 is to be preferred to the B value.

A reason for this investigation was to determine the photometric range of EX Lup, which with that of PV Cep seemed to be the largest among the known EXors (Herbig 1989). Despite all the foregoing adjustments, the corrected V range of 5.1 mag. remains nearly the same as the original Bateson–Jones value of 5.3 mag.

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