Infrared Variation of Blazars

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ABSTRACT

In this paper, the historical infrared (JHK) data compiled from the published literature are presented here for 30 blazars. Maximum near-IR variations are found and compared with the optical ones. Relations between color index and magnitude and between color-color indices are discussed individually. For the color-magnitude relation, some objects (0215+015, 0422+004, and 1641+395) show that the color index increases with magnitude indicating that the spectrum flattens when the source brightens while 1253-055 shows complex behaviour: the spectrum steepens when the source dims in J band and the spectrum flattens when the source dims further suggesting that the emission mechanism consists of, at least, two parts in this case. From the color indexes, we have that the spectral indexes are in the range of $\alpha_{IR} = 0.77 \sim 2.37 \ (f_\nu \propto \nu^{-\alpha})$.

Subject headings: Variability–Infrared–Blazars
1. Introduction

While the nature of active galactic nuclei (AGNs) is still an open problem, the study of AGNs variability can yield valuable information about their nature. Photometric observations of AGNs are important to construct light curves and to study variability behavior over different time scales. In AGNs, some long-term optical variations have been observed and in some cases claimed to be periodic (see Fan et al. 1998a).

Blazars are AGNs characterized by compact radio core, high and variable radio and optical polarization, superluminal radio components. The continuum emissions are rapidly variable at all frequencies with amplitude and rapidity increasing with frequency (see Kollgaard 1994). Blazars include BL Lac objects, optically violently variable quasars (OVVS), highly polarized quasars (HPQs), flat spectrum radio quasars (FSRQ) and core dominated quasars (CDQ). All those objects are basically the same thing (Fugmann 1989; Impey et al. 1991; Valtaoja et al. 1992; Will et al. 1992).

Before γ-ray observations were available, Impey & Neugebauer (1988) found that the infrared emission (1-100 µm) dominates the bolometric luminosities of blazars. The infrared emissions are also an important component for the luminosity even when the γ-ray emissions are included (von Montigny 1995). Study of the infrared will provide much information of the emission mechanism. The long-term infrared variations have been presented for some selected blazars in a paper by Litchfield et al. (1994).

Infrared observations have been done for blazars for more than 20 years. Neugebauer et al. (1979) presented the infrared variations for a few blazars with the observation time being back to the 1960’s. The infrared observations done over a period of 8 years have also been presented for some selected blazars in the paper by Litchfield et al. (1994). But there are no available long-term infrared variations in the literature for all these objects. Recently, we have obtained the long-term infrared variation for 40 radio selected BL Lac objects (Fan & Lin 1999a). In this paper, we mainly present the long-term infrared (J, H, and K bands) light curves for some
blazars and discuss the variation properties. The compiled data available from the author (e-mail: jhfan@guangztc.edu.cn). This paper has been arranged similar to our previous paper (Fan & Lin 1999a). In section 2, we review the literature data and light curves; in section 3, we discuss the variations and give some remarks for each object, and a short summary.

2. Near-infrared Light Curves

2.1. Data from Literature

Infrared observations are available since the end of the 1960s. We compiled the data from 47 publications. They are listed in table 1 & 2, which gives the observers in Col. 1. and the telescope(s) used in Col.2. For the J, H, and K magnitudes, they are listed in an table 4 in electronic form. In table 4, Col. 1 gives the name; Col. 2. the JD time; Col. 3, the J magnitude; Col. 4 the uncertainty for J; Col. 5, the H magnitude; Col. 6, the uncertainty for H; Col. 7, K magnitude; Col. 8, the uncertainty for K.

2.2. Data Analysis

The flux densities from the literature had been converted back to magnitudes using the original formulae. In the literature, different telescopes are used, different telescopes use photometers with slightly different filter profiles, resulting in slightly different calibration standards and zero-points, but the uncertainty aroused by the different systems is no more than a few percent.

The magnitude is dereddened using $A(\lambda) = A_V(0.11\lambda^{-1} + 0.65\lambda^{-3} - 0.35\lambda^{-4})$ for $\lambda > 1\mu m$ and $A_V = 0.165(1.192 - \tan b)\csc b$ for $|b| \leq 50^\circ$ and $A_V = 0.0$ for $|b| > 50^\circ$ (Cruz-Gonzalez & Huchra 1984, hereafter CH (84); Sandage 1972; Fan et al. 1998b). It is clear that some objects have many observations while others have only a few data points, in Figures 1-15, we show only those with more observations.

For data shown in Figs. d - i of each object we have performed linear fit with uncertainties in
both coordinates considered (see Press et al. 1992 for detail),

\[ y(x) = a + bx \] (1)

In principle, \( a \) and \( b \) can be determined by minimizing the \( \chi^2 \) merit function (i.e. equation 15.3.2 in Press et al. book)

\[ \chi^2(a, b) = \sum_{i=1}^{n} (y_i - a - bx_i)^2 w_i \] (2)

where \( \frac{1}{w_i} = \sigma_{y_i}^2 + b^2 \sigma_{x_i}^2 \), \( \sigma_{y_i} \) and \( \sigma_{x_i} \) are the \( x \) and \( y \) standard deviations for the \( i \)th point

Unfortunately, the occurrence of \( b \) in the denominator of the above \( \chi^2 \) merit function, resulting in equation \( \frac{\partial \chi^2}{\partial b} = 0 \) being nonlinear makes the fit very complex, although we can get a formula for \( a \) from \( \frac{\partial \chi^2}{\partial a} = 0 \):

\[ a = \frac{\sum_i w_i (y_i - bx_i)}{\sum_i w_i} \] (3)

Minimizing the \( \chi^2 \) merit function, equation (2), with respect to \( b \) and using the equation (3) for \( a \) at each stage to ensure that the minimum with respect to \( b \) is also minimized with respect to \( a \), we can obtain \( a \) and \( b \). As Press et al. stated, the linear correlation coefficient \( r \) then can be obtained by weighting the relation (14.5.1) terms of Press et al. (1992). Finding the uncertainties, \( \sigma_a \) and \( \sigma_b \), in \( a \) and \( b \) is more complicated (see Press et al. 1992). Here, we have not performed this. For the data whose uncertainties were not given in the original literature are not included in our linear fit or in Fig. d-i, but they are included in the light curves (Fig. a - c).

As discussed in the paper of Massaro & Trevese (1996) (also see Fan & Lin 1999a), there is a statistical bias in the spectral index-flux density correlation. Following their suggestion, we considered the relation between magnitude in one band and the color index obtained from two other bands to avoid this bias. The relations are shown in Fig. d-f.

3. Discussion
3.1. Variations

Blazars are variable at all wavelengths. For blazars with enough infrared data, we presented their variability properties in Table 3, which gives the name in Col. 1, redshift in Col. 2, reddening correction, $A_V$, in Col. 3, largest optical polarization ($P_{opt}$) in Col. 4, maximum amplitude optical variation ($m_{opt}$) in Col. 5, maximum amplitude variations in J, H, and K in Col. 6, 7, and 8, the averaged color index (J-H) and (H-K) in Col. 9, and 10, the uncertainty in Col. 9 and 10 is the one sigma deviation. The infrared variations are very large for some objects. For variation, it is reasonable for larger variation to correspond to shorter wavelength, but some objects show different behaviour in the present paper. It is interesting to note that the object having steepening spectrum when the source brightens shows that the variation at the longer wavelength is larger than that at the shorter one. Most objects showing large optical variation also show large infrared variations and high polarizations, large variation and high polarization are associated. For the color-indices, we have that (J-H) covers a range of 0.66 to 1.44 suggesting a range of spectral index $\alpha = 0.77$ to 2.37 since $(J-H) = 0.300\alpha + 0.43$ (Sitko, private communication).

It is possible that more than one mechanism is responsible for the emission in the infrared region, i.e., it is reasonable that a nonvariable or slowly varying near-IR component, such as the stars in the parent galaxy, is present in the spectrum of AGNs. In this sense, when the source is bright, the spectrum is observed to steepen when the source dims, as expected from a synchrotron component which experiencing radiative energy losses, but when the source dims further, because of the presence of the underlying near-IR emission, the spectrum will flattens with the source getting faint (Fan 1999a,b). So, the investigation of the relation between spectrum index and flux can throw some lights on the components of near-IR emission mechanism, particularly when the source is faint. Our analysis in the present paper indicates that there are perhaps at least two components in the near-IR region of 3C 279, but it should be confirmed with more observations.

Following the variation properties are discussed for individual object.
3.2. Remarks

3.2.1. 0109+224, \( z = ? \)

This polarized \( (P_{opt.} = 17.26 \pm 1.63\%, P_{IR} = 13.87 \pm 0.74\%, \text{Mead et al. 1990}) \) object shows a variation of \( \Delta B = 3.07 \) (Bozyan et al. 1990). The infrared variations are less than in the optical one, no correlation is found for color index and magnitude. There is an indication of a correlation between \( (J-K) \) and \( (J-H) \), but not for other color indices (see Fig. 1).

3.2.2. 0215+015, \( z_{abs} = 1.686 \)

It is one of the most luminous \( (B = 14.5 \sim \geq 19.5 \text{ Pettini et al. 1983}) \) known BL Lac objects and polarized at \( P_{IR} = 17.4 \pm 1.1\% \) in H band (Holmes et al. 1984) and \( P_{opt} = 20\% \) (Angel & Stockman 1980). There are only a few infrared data in the literature, which show a positive correlation between color index and magnitude suggesting the spectrum flattens when the source brightens: \( (H-K) = 0.08J - 0.26 \) with \( r = 0.97 \) and \( p = 1.2\% \); \( (J-K) = 0.16H - 0.36 \) with \( r = 0.89 \) and \( p = 4.5\% \). Those color-magnitude correlations were obtained based on 4 points, so they should be confirmed with more observations. For color indices, there is also an indication of correlations between \( (J-K) \) and \( (J-H) \) and \( (H-K) \) as well with \( p < 5\% \) (see Fig. 2).

3.2.3. 0301-243, \( z = ? \)

This moderately variable \( (\Delta m = 0.89, \text{ Pica et al. 1988}) \) object has been observed in the infrared for 3 nights showing a variation of 0.20 mag and color indices of \( (J-H) = 0.81\pm0.05 \), \( (J-K) = 1.52\pm0.03 \) and \( (H-K) = 0.71\pm0.05 \). It is polarized at \( P_{opt.} = 10.97\% \) (Impey & Tapia 1988).
3.2.4. 0323+022, \( z = 0.147 \)

It is one of the X-ray selected BL Lac objects (XBLs) showing extremely rapid variation. An X-ray variation over a time scale of 30 seconds was observed by Feigelson et al. (1986), who also noticed a brightness decrease of 1.3 mag within one day in the optical region. Polarizations of \( P_{\text{opt.}} \sim 2 - 9\% \) (Feigelson et al. 1986) and \( P_{\text{IR}} = 4.65 \pm 1\% \) (Mead et al. 1990) are reported. It can be obtained that the optical spectral index is strongly associated with the brightness (\( V = -(1.52 \pm 0.04)(B - V) + 17.07 \pm 0.02 \), with a correlation coefficient of \( r = -0.967 \)) when the optical observations (Feigelson et al. 1996) are taken into account. There are only a few infrared data for this object showing variations of \( \Delta J = 0.30, \Delta H = 0.52 \) and \( \Delta K = 0.96 \).

3.2.5. 0336-019, CTA26, \( z = 0.852 \)

There are only 4 nights of infrared data for this polarized (\( P_{\text{opt}} = 19.4\% \), Impey & Tapia 1990) and variable (\( \Delta m = 1.4 \), Pica et al. 1988) object showing \( J = 15.45, H = 15.00-15.96, \) and \( K = 14.57-15.99 \) and color indices of \( (J-H) = 0.45 \pm 0.32, (J-K) = 0.88 \pm 0.29, \) and \( (H-K) = 0.43 \pm 0.25 \).

3.2.6. 0406+121, \( z = 1.02 \)

There are only 6 nights of infrared data for this faint (\( V = 20.4 \), Rieke et al. 1979) object showing variations of \( \Delta H = 0.90, \) and \( \Delta K = 1.78 \) and color indices of \( (J-H) = 1.13 \pm 0.07, (J-K) = 2.11 \pm 0.07 \) and \( (H-K) = 0.98 \pm 0.07 \).

3.2.7. 0420-014, OA129, \( z = 0.915 \)

The infrared data show variations of \( \Delta J = 2.46, \Delta H = 2.88 \) and \( \Delta K = 2.61 \) and color indices of \( (J-H) = 0.80 \pm 0.16, (J-K) = 1.65 \pm 0.10, \) and \( (H-K) = 0.86 \pm 0.16 \). A polarization of \( P_{\text{opt}} = 20.19 \pm 1.26\% \) and an optical variation of \( \Delta m = 2.8 \) are reported in the paper of Angel &
Stockman (1980). In addition, the optical polarization is wavelength-dependent with polarization being higher at longer wavelength (Smith et al. 1988). The limited data indicate that K is anti-correlated with (J-H), but this kind of correlation is far from certainty.

3.2.8. 0422+004, z =?

An optical variation of $\Delta m = 2.2$ (Branly et al. 1996) and high and variable polarizations are known for this object. The infrared polarization increases from 13.6% to 19.8% when the source dimmed by 0.3 mag in K (Holmes et al. 1984) and in other case it decreases from 20.27% to 12.25% in two days when the source does not show significant variation, during which period the optical polarization also decreases from 22.14% to 13.69% (Mead et al; 1990). The infrared data show that the infrared variations are similar to the optical ones. A correlation between (H-K) and J: (H-K) = -0.51 + 0.1J with $r = 0.50$ and $p = 4.4 \times 10^{-3}$. There are close correlations between (J-K) and (J-H) and (H-K): (J-K) = 0.17 + 1.80(J-H) with $r = 0.81$ and $p = 5.4 \times 10^{-8}$; (J-K) = 0.19 + 1.76(H-K) with $r = 0.789$ and $p = 2.8 \times 10^{-7}$ (see Fig. 3).

3.2.9. 0521-365, z = 0.055

This steep-spectrum radio source was identified with an N galaxy by Bolton et al. (1965b), a redshift of $z_{em} = z_{abs} = 0.055$ was shown by Danziger et al. (1978). A Polarization of $P_{opt} \sim 11\%$ (Bailey et al. 1983) and a variation of $\Delta m = 1.4$ (Angel & Stockman, 1980) are reported. The infrared data show correlations between (J-K) and (J-H) and (H-K) (see Fig. 4). (J-K) = 0.36 + 1.40(J-H) with $r = 0.89$ and $p = 2.4 \times 10^{-4}$; (J-K) = -0.32 + 2.62(H-K) with $r = 0.756$ and $p = 5.0 \times 10^{-3}$. The infrared variation in K is similar to that in the optical band.
3.2.10. 0548-322, \( z = 0.069 \)

The radio source was found and identified with a 15 mag galaxy, photometry yield V=15.5±0.1, (B-V) = 0.57±0.02, and (U-B) = -0.30±0.03 (see Disney 1974). The infrared data indicate that the variation in K is larger than those in J and H, the color indices show an anti-correlation between (J-H) and (H-K): (H-K) = 1.12 - 0.94(J-H) with \( r = -0.76 \) and \( p = 2.67\% \) (see Fig. 5)

3.2.11. 0716+322, \( z =? \)

The 4 nights of infrared data show variations of \( \Delta J = 2.06, \Delta H = 2.05 \) and \( \Delta K = 2.51 \) and color indices of \( (J-H) = 0.73\pm0.04, (J-K) = 1.50\pm0.02 \) and \( (H-K) = 0.84\pm0.12 \). \( P_{\text{opt}} = 7.43\pm0.56\% \) and a wavelength-dependence of \( P, dP/d\lambda < 0 \) are observed by Smith et al.(1988).

3.2.12. 0736+017, OI+061, \( z = 0.191 \)

This nearby quasar has shown a variation of \( \Delta m = 1.35 \) (Pica et al. 1988). The optical polarization \( (P_{\text{opt}} = 0\% - 6\%) \) is less than the infrared one \( (P_{IR} = 7.3 \pm 4.3\%, \) Holmes et al. 1984). The infrared light curves show that the source has been brightening with time, but some brightness fluctuations also show up. \( (J-K) \) is found to be correlated with \( (J-H) \) and \( (H-K) \): \( (J-K) = 0.36 + 1.64(J-H) \) with \( r = 0.83 \) and \( p = 1.2 \times 10^{-3} \) \( (J-K) = -0.11 + 2.04(H-K) \) with \( r = 0.73 \) and \( p = 7.0 \times 10^{-3} \). Complex associations can be seen for color index and magnitude in Fig. 6,e,f (see Fig. 6).

3.2.13. 0823-223, \( z > 0.91 \)

This polarized \( (P_{\text{opt}} = 4\% - 10.75\%, \) Impey & Tapia 1988) object has shown an optical variation of \( \Delta V = 1.5 \) and \( (V-K) = 3.7 \). The optical spectrum steepens when the source brightens
\[ \alpha_{\text{opt}} = 1.7 \pm 0.02 \text{ when } V = 15.7, \text{ and } \alpha_{\text{opt}} = 2.1 \pm 0.1 \text{ when } V = 16.6, \text{ Falomo } 1990 \]. It has been observed in the infrared on some occasions, the data show an indication of an anti-correlation between color index and magnitude, which is different from the optical behaviour: \( (J-H) = 3.19 - 0.20K \) with \( r = -0.87 \) and \( p = 1.2\% \). For the color indices, \( (J-K) \) is correlated with \( (J-H) \) and \( (H-K) \) (see Fig. 7).

### 3.2.14. 0912+297, OK222, \( z = ? \)

There are only 6 nights of infrared data for this polarized \( P_{IR} = 13.5 \sim 2.8\% \), Holmes et al. 1984, \( P_{\text{opt}} = 13\% \), Angel & Stockman 1980) object showing variations of \( \Delta H = 2.27 \), and \( \Delta K = 2.41 \) and color indices of \( (J-H) = 0.71 \pm 0.08 \), \( (J-K) = 1.53 \pm 0.11 \) and \( (H-K) = 0.85 \pm 0.20 \). The optical variation (\( \Delta m = 2.25 \), Bozyan et al. 1990) is similar to in the infrared one.

### 3.2.15. 1034-293, \( z = 0.311 \)

It is polarized at \( P_{\text{opt}} = 13.8 \pm 1.18\% \) (Wills et al. 1992). The limited infrared data give a variation of 1 mag in K and color indices of \( (J-H) = 1.00 \pm 0.05 \), \( (J-K) = 1.95 \pm 0.15 \), and \( (H-K) = 0.95 \pm 0.20 \).

### 3.2.16. 1055+018, \( z = 0.888 \)

There are only two nights of infrared data for this polarized (\( P_{\text{opt}} = 6\% \), Impey & Tapia 1988) object showing a variation of \( \Delta H = 0.54 \) and color indices of \( (J-H) = 0.66 \pm 0.14 \), \( (J-K) = 1.82 \pm 0.15 \), and \( (H-K) = 1.16 \pm 0.13 \).
3.2.17. 1156+295, 4C29.45, Ton599, \( z = 0.728 \)

This variable (\( \Delta m = 5.0 \), Branly et al. 1996) object shows high and variable polarizations (\( P_{IR} = 28.06\% \), \( P_{opt}=28\% \), Holmes et al. 1984; Mead et al. 1990). The optical polarization increase from 5\% to 20\% between 1984 June 9 and 10 (Smith 1996). During the simultaneous observations, 1156+295 did not show significant change in the shape of the IR-UV spectrum when the flux varied (Glassgold et al. 1983). The infrared light curves show two double-peaked outbursts. There are positive correlations between (J-K) and (J-H) as well as (H-K), but the association between color index and magnitude is complex, no definite correlation can be obtained (see Fig. 8), which is similar to the result found in the optical band by Glassgold et al (1983)(also See Fan 1999b).

3.2.18. 1218+304, RS4, \( z = 0.130 \)

The X-ray source is one of the best observed in the “2A” catalogue of high galactic-latitude sources (Cooke et al. 1978; Wilson et al. 1979). An optical polarization of \( P_{opt} = 6.6\% \) is known (Wills et al. 1992). There are 4 nights of infrared data showing a variation of \( \Delta K = 0.91 \) and color indices of \( (J-H) = 0.67\pm0.10 \), \( (J-K) = 1.50\pm0.29 \), and \( (H-K) = 0.78\pm0.16 \).

3.2.19. 1244-255, \( z = 0.638 \)

There are only 3 nights of data showing a variation of \( \Delta H = \Delta K = 0.95 \) and color indices of \( (J-H) = 0.86\pm0.25 \), \( (J-K) = 1.69\pm0.22 \), and \( (H-K) = 0.82\pm0.27 \). An optical polarization of \( P_{opt} = 8\% - 12\% \) (Impey & Tapia 1988) and a variation of \( \Delta V = 2.0 \) (Bozyan et al. 1990) are reported.
3.2.20. 1253-055, 3C279, $z = 0.536$

3C279 is a well known member of OVVs, a large optical variation of $\Delta B \geq 6.70$ mag (Eachus & Liller 1975) and a highly optical polarization of $P_{\text{opt}} = 44\%$ (see Fan et al. 1996) and a possible variability period of 7-year (Fan 1999) are reported. It is the prototype of superluminal radio sources and shows a violently optical brightness increase of 2.0 mag during an interval of 24 hours (Webb et al. 1990). The infrared light curves show 3 outbursts. The (J-K) is strongly associated with (J-H) and (H-K). There is a positive correlation between color index and magnitude (see Fig. 9). For (H-K) and J, there is a positive correlation between them when J is brighter than 14 magnitude but there is a negative correlation between them when the source is fainter than 14 magnitude. From above discussion, it is possible that the emission mechanism consists of two components in the case (also see Fan 1999a,b).

3.2.21. 1510-089, $z = 0.361$

1510-089 is one of the largest variable objects with $\Delta B = 5.4(11.8 - 17.2)$ (Bozyan et al. 1990). A maximum optical polarization of $P_{\text{opt}} = 14.45\%$ is reported and the optical polarization is found to be wavelength-dependent with $dP/\lambda > 0$ (see Smith et al. 1988), the infrared polarization is $P_{\text{IR}} = 9.07\%$ (Mead et al. 1990). The infrared light curves show a clear brightness increase with the variation in the shorter wavelength being smaller than that in the longer one. (J-K) is correlated with (H-K), no correlated between color index and magnitude can be found from the available data (see Fig. 10).

3.2.22. 1641+395, 3C345, $z = 0.595$

3C345 is one of the well studied quasars (Bregman et al. 1986a; Smith 1996, and references therein), it gives us a well-documented example of a clear connection between brightness and polarization as well as polarization angle (Smith 1996). It is polarized at $P_{\text{IR}} = 0\% - 20.27\%$
(Mead et al. 1990) and $P_{opt} = 5\% - 35\%$ (Bregman et al. 1986a). The optical variation of $\Delta m = 2.5$ (Bregman et al, 1996a) is smaller than that in the infrared variation of $\Delta J = 3.16$ mag. The infrared observations in the paper of Bregman et al (1986a) are also included in our discussion although the paper is not listed in table 1 for they have not indicated their telescopes used. The infrared light curves show clearly two outbursts separating by about 11.3 years which is consistent with the 11.4-year optical outburst period (Webb et al. 1988, also see Fan et al. 1998a for summary). For the color indices, (J-K) is found correlated strongly with (J-H) and (H-K). A correlation is found between color index and magnitude (see Fig. 11): $(J-K) = 0.49 + 0.10H$ with $r = 0.555$ and $p = 7.6 \times 10^{-6}$, $(J-K) = 0.27 + 1.76 (J-H)$ with $r = 0.80$ and $p = 6.6 \times 10^{-14}$, $(J-K) = 0.003 + 1.93 (H-K)$ with $r = 0.82$ and $p = 1.0 \times 10^{-14}$.

3.2.23. 1717+177, OT129, $z = ?$

It is identified by Hoskins et al. (1974) and Condon et al. (1977) with a starlike object of 18.5 mag (also see Veron & Veron, 1993). There are only 4 nights of infrared data for this polarized ($P_{opt.} = 27\%$, Angel & Stockman 1980; $P_{IR} = 16.85\%$, Mead et al. 1990) object showing a variation of $\Delta K = 1.89$ and color indices of (J-H) = 0.92±0.03, (J-K) = 1.90±0.03, and (H-K) = 0.98±0.03.

3.2.24. 1722+119, $z = ?$

This object is very interesting, its polarizations ($P_{opt} = 17.6\pm 1.0\%$ and $P_{IR} = 11.9\pm 1.1\%$) are at a typical level of a radio selected BL Lac object (RBL) and are strongly wavelength-dependent ($dP/d\lambda = -5.7 \pm 1.2\%$), the X-ray to optical luminosity ratio is comparatively much higher and is similar to the values among XBLs (Brissenden et al. 1990). The 4 nights of data show a variation of 1.0 mag in J, H, and K and color indices of (J-H)=0.71±0.07, (J-K)=1.38±0.06, and (H-K)=0.67±0.04.
3.2.25. 1921-293, OV − 236, z = 0.352

An optical variation of $\Delta m = 2.64$ (Pica et al. 1988) and polarizations of $P_{opt.} = 16.89\%$ and $P_{IR} = 13.94\%$ (Mead et al. 1990) are reported for this object. The H light curve shows a sharp brightness decrease, which leads H variation to be greater than the optical variation. During the sharp decreasing period, there were no observations for J or K. (J-K) is found correlated with (J-H) and (H-K) (see Fig. 12): (J-K) = 0.63 + 1.30 (J-H) with $r = 0.80$ and $p = 9.1 \times 10^{-4}$, (J-K) = 0.17 + 1.80 (H-K) with $r = 0.50$ and $p = 4.7\%$.

3.2.26. 2155-304, z = 0.117

It is the brightest XBL in the UV. The X-ray, UV, and optical light curves are well-correlated, suggesting a common origin of the optical through X-ray emissions, and the X-rays lead the UV by $\sim 2-3$ hours (Edelson et al. 1995). It has been extensively studied in the UV and X-rays (Pesce et al. 1996; Pian et al. 1996, and reference therein). Polarizations of $P_{opt} = 14.2\%$ (Pesce et al. 1996) and $P_{IR} = 9.4 \pm 0.7\%$ (Mead et al. 1990) and an optical variation of $\Delta m_V = 1.85$ (Fan & Lin 1999b) are reported. There is an indication for (J-K) to be correlated with (J-H) and (H-K) and H as well (see Fig. 13): (J-K) = 1.04 - 0.04H with $r = -0.37$ and $p = 1.9\%$.

3.2.27. 2208-137, z = 0.392

The blazar is unusually showing symmetric double radio lobes (Antonucci & Ulvestad 1984). The double-lobed blazars are important in establishing a kinship between blazars and normal double radio sources (Antonucci et al. 1987). The 7 nights of infrared data show a moderate variation of 0.3 mag in the infrared and color indices of (J-H) = 0.98±0.14, (J-K) = 2.10±0.14, and (H-K) = 1.11±0.01. Polarizations of $P_{IR} = 9.32\%$ (Mead et al. 1990) and $P_{opt} = 8.71 \pm 0.38\%$ (Moore & Stockman 1981) are known.
3.2.28. 2223-052, 3C446, ($z_{em}=1.404$)

The flat spectrum radio source is the prototype of the class of violently variable quasars (Bregman et al. 1986b). During the optical outbursts, the spectral index shows complex dependence on the brightness, sometimes the slope of the optical continuous is steeper (Sandage et al. 1966) and sometimes flatter (Visvanathan 1973) than during quiescent states. On occasions, week emission lines have been observed in the optical region, the intensities of which do not change with the spectral flux (Sandage et al. 1966, see also Garilli & Tagliferri 1986). Polarizations of $P_{opt} = 4 \sim 17.3\%$ (Impey & Tapia 1990), $P_{TR} = 16\%$ (Impey et al. 1982) and $P_{10\,GHz} = 4\%$ (Mead et al. 1990) and an optical variation of $\Delta m = 5.0$ (Branly et al. 1996) are reported. The infrared light curves shows a clear outburst, after which the brightness decrease rapidly by about 4 mag in H. (J-K) is found correlated with (J-H) and (H-K), but the correlation between color index and magnitude is complex: There is a positive connection between (H-K) and J but a negative correlation between (J-H) and K (see Fig. 14): (H-K) = 0.06 + 0.06J with $r = 0.589$ and $p = 3.8 \times 10^{-4}$, (J-H) = 1.19 - 0.02K with $r = -0.35$ and $p = 3\%$.

3.2.29. 2251+158, 3C454.3, $z = 0.859$

A polarization of $P_{opt} = 0\% - 16.0\%$ and $\Delta m = 2.3$ are reported in the paper of Angel & Stockman (1980). A variability of 0.5 mag over a time scale of one day has also been observed in this object (Lloyd, 1984). Smith et al (1988) observed this object on 1986 Dec. 23, 1987 June 23 and 24 and found the optical polarization is less than 6\% and the polarization is wavelength-dependent with $dP/d\lambda > 0$. The light curve indicates a variation of 1.57 mag in K which is smaller than in the optical one. (J-K) is found to be correlated with (J-H) and (H-K) (see Fig. 15): (J-K) = 0.48 + 1.52 (J-H) with $r = 0.94$ and $p = 1 \times 10^{-4}$, (J-K) = -0.44 + 2.36 (H-K) with $r = 0.86$ and $p = 2.3 \times 10^{-3}$. 
3.2.30. 2345-167, z = 0.576

Smith et al. (1988) found that the optical polarization ($P_B = 4.78\%$, $P_R = 11.81\%$, and $P_I = 11.90\%$) wavelength-dependent. The maximum optical polarization $P_{opt} = 3 \sim 19\%$ (Angel & Stockman 1980) and maximum optical variation of $\Delta m = 2.55$ (Bozyan et al. 1990) are reported. There are only two nights of infrared observations showing $J = 16.54$, $H = 15.61-15.85$ and $K = 14.58$ and color indices of $(J-H) = 0.93 \pm 0.22$, $(J-K) = 1.96 \pm 0.25$ and $(H-K) = 1.03 \pm 0.21$.

3.3. Summary

In this paper, the infrared variations are presented for 30 blazars, the light curves are shown in Fig. 1 to 15 for 15 objects with enough observations. The amplitude variation in the optical and infrared bands are compared. For the color-magnitude relation, some objects (0215+015, 0422+004, and 1641+395) show a color index increasing with magnitude, indicating that the spectrum flattens when the source brightens while 3C 279 shows a complex correlation between $(H-K)$ and $J$ meaning that the emission mechanism consists of two components, the rest objects do not show any clear tendency between color index and magnitude. The color indexes suggest that the spectral indexes are in the range of $\alpha_{IR} = 0.77$ to 2.37.

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Zekl, H. et al. 1981, A&A, 103, 342
| Observer(s)                        | Telescope(s)     |
|-----------------------------------|------------------|
| Allen (1976)                      | UM/UCSD 1.5m     |
| Allen et al (1982)                | A-A 3.9m; UKIRT 3.8m |
| Bersonelli et al (1992)           | ESO 3.6m & 2.2m  |
| Brindle et al (1986)              | UKIRT 3.8m       |
| Brissenden et al (1990)           | AUN 2.3m         |
| Brown et al (1989)                | UKIRT 3.8m       |
| Cruz-Gonzales & Huchra (1984)     | CTIO 4m          |
| Cutri et al (1985)                | KPNO 1.5m        |
| Falomo et al (1993)               | ESO 2.2m         |
| Falomo (1990)                     | ESO 2.2m         |
| Garcia-Lario et al (1989)         | TCS 1.5m         |
| Gear (1993)                       | UKIRT 3.8m       |
| Gear et al (1985, 1986)           | UKIRT 3.8m       |
| Glass (1981)                      | Sutherland 1.88m |
| Glassgold et al (1983)            | UKIRT 3.8m       |
| Holmes et al (1984)               | Palomar Mt. 5m   |
| Impey et al (1982, 1984)          | UKIRT 3.8m       |
| Kidger & Allan (1988)             | TCS 1.5m         |
| Kidger & Casares (1989)           | TCS 1.5m         |
| Kidger et al (1992)               | TCS 1.5m         |
| Kidger et al (1993)               | TCS 1.5m         |
| Kitilainen et al (1992)           | UKIRT 4m         |
| Observer(s)             | Telescope(s)                      |
|------------------------|-----------------------------------|
| Landau et al (1986)    | UKIRT 3.8m; Hale 5m &             |
|                        | Mount Lemnon 1.5m                 |
| Ledden et al (1981)    | UM/UCSD 1.5m                      |
| Lepine et al (1985)    | ESO 3.6m                          |
| Litchfield et al (1994)| ESO 2.2m                          |
| Maraschi et al (1994)  | Sutherland 1.9m                    |
| Massaro et al (1995)   | TIGRO 1.5m & ESO 1.0m             |
| Mead et al (1990)      | UKIRT 3.8m                        |
| Neugebauer et al (1979)| Hale 5.0m                         |
| O’Dell et al (1978)    | UM/UCSD 1.5m                      |
| Puschell & Stein (1980)| UM/UCSD 1.5m                      |
| Rieke et al (1977, 1979)| UOA 90inch & 61 inch             |
| Robson et al (1983)    | UKIRT 3.8m                        |
| Robson et al (1988)    | UKIRT 3.8m                        |
| Roelling et al (1986)  | UKIRT 3.8m                        |
| Sitko et al (1982, 1983)| UM/UCSD 1.5m                     |
| Sitko & Sitko (1991)   | KPNO 1.3m & 1.5m                   |
| Smith et al (1987)     | KPNO 2.1m                         |
| Takalo et al (1992)    | TCS 1.5m                          |
| Tanzi et al (1989)     | ESO 1.5m & 3.6m                    |
| Worrall et al (1986)   | MU/UCSD 1.5m                      |
Table 3: Observed Largest Variations of Blazars

| Name     | z     | $A_V$ | $P_{opt}$ (%) | $\Delta m_{opt}$ | $\Delta J$ | $\Delta H$ | $\Delta K$ | (J-H)   | (H-K)   |
|----------|-------|-------|---------------|------------------|------------|------------|------------|---------|---------|
| 0109+244 |       | 0.09  | 17.3          | 3.07             | 1.55       | 1.56       | 1.58       | 0.80 ± 0.22 | 0.87 ± 0.11 |
| 0215+015 | 1.715 | 0.0   | 20.0          | 5.0              | 2.00       | 2.69       | 2.52       | 0.83 ± 0.05 | 0.81 ± 0.09 |
| 0323+022 | 0.147 | 0.068 | 9.0           | 1.3              | 0.30       | 0.52       | 0.97       | 0.73 ± 0.10 | 0.48 ± 0.10 |
| 0420-014 | 0.915 | 0.163 | 20.0          | 2.8              | 2.46       | 2.88       | 2.61       | 0.80 ± 0.16 | 0.86 ± 0.16 |
| 0422+004 |       | 0.20  | 22.0          | 2.2              | 1.69       | 3.25       | 3.41       | 0.82 ± 0.11 | 0.82 ± 0.07 |
| 0521-365 | 0.055 | 0.176 | 11.0          | 1.4              | 0.74       | 0.89       | 1.25       | 0.80 ± 0.16 | 0.69 ± 0.21 |
| 0548-322 | 0.069 | 0.283 | 0.0           | 0.40             | 0.32       | 0.55       | 0.71       | 0.45 ± 0.09 | 0.45 ± 0.09 |
| 0716+332 |       | 0.405 | 7.4           | 2.06             | 2.05       | 2.01       | 0.73       | 0.84 ± 0.12 | 0.84 ± 0.12 |
| 0736+017 | 0.191 | 0.863 | 6.0           | 1.35             | 2.28       | 2.07       | 2.71       | 0.81 ± 0.14 | 0.88 ± 0.13 |
| 0823-223 | 0.91  | 0.60  | 11.0          | 1.5              | 1.93       | 2.26       | 2.32       | 0.66 ± 0.13 | 0.65 ± 0.13 |
| 0912+297 |       | 0.05  | 13.0          | 2.25             | 0.40       | 2.27       | 2.41       | 0.71 ± 0.08 | 0.85 ± 0.20 |
| 1156+295 | 0.728 | 0.0   | 28.0          | 5.0              | 4.47       | 3.82       | 3.97       | 0.84 ± 0.09 | 0.91 ± 0.09 |
| 1253-055 | 0.536 | 0.0   | 44.0          | 6.7              | 4.57       | 4.26       | 4.45       | 0.93 ± 0.12 | 0.95 ± 0.09 |
| 1641+395 | 0.595 | 0.09  | 35.0          | 2.5              | 3.16       | 3.13       | 3.15       | 0.87 ± 0.14 | 0.95 ± 0.10 |
| 1510-089 | 0.360 | 0.10  | 14.0          | 5.4              | 0.88       | 0.97       | 1.25       | 1.14 ± 0.05 | 1.08 ± 0.09 |
| 1921-293 | 0.352 | 0.47  | 17.0          | 2.64             | 2.10       | 3.04       | 2.16       | 0.92 ± 0.08 | 0.90 ± 0.09 |
| 2155-304 | 0.117 | 0.0   | 14.2          | 1.85             | 1.26       | 1.88       | 1.24       | 0.66 ± 0.09 | 0.62 ± 0.07 |
| 2223-052 | 1.404 | 0.01  | 17.3          | 5.0              | 3.84       | 3.96       | 3.77       | 0.93 ± 0.11 | 0.92 ± 0.17 |
| 2251+158 | 0.859 | 0.10  | 19.0          | 2.5              | 0.76       | 1.31       | 1.57       | 0.68 ± 0.11 | 0.84 ± 0.09 |
Figure Captions

Fig. 1. Light curves and color index properties for 0109+224. a: J light curve; b: H light curve; c: K light curve; d: (J-H) vs. K; e: J-K vs. K; f: (H-K) vs. K; g: (H-K) vs. (J-H); h: J-K vs. (J-H); i: J-K vs. (H-K)

Fig. 2. Light curves and color index properties for 0215+015

Fig. 3. Light curves and color index properties for 0422+004

Fig. 4. Light curves and color index properties for 0521-365

Fig. 5. Light curves and color index properties for 0548-322

Fig. 6. Light curves and color index properties for 0736+017

Fig. 7. Light curves and color index properties for 0823-223

Fig. 8. Light curves and color index properties for 1156+295

Fig. 9. Light curves and color index properties for 1253-055

Fig. 10. Light curves and color index properties for 1510-089

Fig. 11. Light curves and color index properties for 1641+395

Fig. 12. Light curves and color index properties for 1921-293

Fig. 13. Light curves and color index properties for 2155-304

Fig. 14. Light curves and color index properties for 2223-052

Fig. 15. Light curves and color index properties for 2251+158

Table 4: Near-Infrared Observations of 40 Radio-Selected BL Lac Objects

| Name | JD 2400000+ | J | σ J | H | σ H | K | σ K |
|------|-------------|---|-----|---|-----|---|-----|
| (1)  | (2)         | (3)| (4) | (5)| (6) | (7)| (8) |
Fig. 1.— Light curves and color index properties for 0109+224.  

- **a**: J light curve;  
- **b**: H light curve;  
- **c**: K light curve;  
- **d**: (J-H) vs. K;  
- **e**: (J-K) vs. K;  
- **f**: (H-K) vs K;  
- **g**: (H-K) vs. (J-H);  
- **h**: (J-K) vs. (J-H);  
- **i**: (J-K) vs. (H-K)
Fig. 2.— Light curves and color index properties for 0215+015.
Fig. 3.— Light curves and color index properties for 0422+004
Fig. 4.— Light curves and color index properties for 0521-365
Fig. 5.— Light curves and color index properties for 0548-322
Fig. 6.— Light curves and color index properties for 0736+017
Fig. 7.— Light curves and color index properties for 0823-223
Fig. 8.— Light curves and color index properties for 1156+295
Fig. 9.— Light curves and color index properties for 1253-055
Fig. 10.— Light curves and color index properties for 1510-089
Fig. 11.— Light curves and color index properties for 1641+395
Fig. 12.— Light curves and color index properties for 1921-293
Fig. 13.— Light curves and color index properties for 2155-304
Fig. 14.— Light curves and color index properties for 2223-052
Fig. 15.— Light curves and color index properties for 2251+158
Infrared Variation of Blazars

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Table 1. Near-Infrared Observations of 30 Blazars.

| Name   | JD 2400000+ | J    | Δ J  | H    | Δ H  | K    | Δ K  |
|--------|-------------|------|------|------|------|------|------|
| 0109+224 | 43848.50    | 11.86| 0.04 |      |      |      |      |
| 0109+224 | 44406.50    | 14.37| 0.03 | 13.44| 0.03 |      |      |
| 0109+224 | 44436.50    | 15.14| 0.03 | 14.24| 0.03 | 13.31| 0.03 |
| 0109+224 | 46386.50    | 13.93| 0.09 | 13.57| 0.10 | 12.44| 0.08 |
| 0109+224 | 46389.50    | 14.25| 0.10 | 13.67| 0.10 | 12.91| 0.08 |
| 0109+224 | 46438.50    | 14.61| 0.26 | 13.34| 0.09 | 12.49| 0.08 |
| 0109+224 | 46439.50    | 13.83| 0.11 | 13.40| 0.09 | 12.47| 0.07 |
| 0109+224 | 46440.50    | 14.54| 0.17 | 13.68| 0.08 | 12.81| 0.06 |
| 0109+224 | 46441.50    | 14.84| 0.08 | 13.97| 0.07 | 13.07| 0.06 |
| 0109+224 | 46763.50    | 13.88| 0.06 | 13.09| 0.03 | 12.39| 0.05 |
| 0109+224 | 46767.50    | 13.59| 0.05 | 12.81| 0.03 | 12.14| 0.03 |
| 0109+224 | 46767.50    | 13.92| 0.05 | 13.01| 0.05 | 12.15| 0.04 |
| 0109+224 | 47113.50    | 14.20| 0.09 | 13.32| 0.05 | 12.39| 0.07 |
| 0109+224 | 47115.50    | 13.28| 0.08 | 12.33| 0.07 |
| 0109+224 | 47376.50    | 14.28| 0.04 | 13.36| 0.03 | 12.56| 0.04 |
| 0109+244 | 46644.50    | 12.95| 0.05 |      |      |      |      |
| 0109+244 | 46647.50    | 12.96| 0.04 |      |      |      |      |
| 0109+244 | 46648.50    | 12.97| 0.05 |      |      |      |      |
| 0109+244 | 46649.50    | 13.03| 0.05 |      |      |      |      |
| 0109+244 | 46650.50    | 13.83| 0.05 | 13.03| 0.05 |      |      |
| 0109+244 | 47004.50    | 13.37| 0.05 |      |      |      |      |
| 0109+244 | 47007.50    | 13.36| 0.05 |      |      |      |      |
| 0109+244 | 47058.50    | 12.93| 0.10 |      |      |      |      |
| 0109+244 | 47060.50    | 13.23| 0.10 |      |      |      |      |
| 0215+015 | 44343.50    | 13.27| 0.02 | 12.44| 0.02 | 11.64| 0.02 |
| 0215+015 | 45345.50    | 13.90| 0.03 | 12.99| 0.02 | 12.14| 0.03 |
| 0215+015 | 45347.50    | 13.80| 0.02 | 12.98| 0.02 | 12.14| 0.03 |
Table 1—Continued

| Name     | JD 2400000+ | J  | \(\Delta J\) | H  | \(\Delta H\) | K  | \(\Delta K\) |
|----------|-------------|----|-------------|----|-------------|----|-------------|
| 0215+015 | 45930.50    | 11.90 | 0.10   | 11.13 | 0.10   | 10.47 | 0.10       |
| 0215+015 | 45931.50    | 11.23 | 0.10   |       |       |       |            |
| 0215+015 | 45933.50    | 12.47 | 0.10   | 11.23 | 0.10   |       |            |
| 0215+015 | 45934.50    | 11.23 | 0.10   |       |       |       |            |
| 0215+015 | 46766.50    | 13.82 | 0.07   | 12.90 | 0.08   |       |            |
| 0215+015 | 47116.50    | 12.99 | 0.10   |       |       |       |            |
| 0301-243 | 44467.50    | 14.18 | 0.02   | 13.41 | 0.02   | 12.67 | 0.02       |
| 0301-243 | 47749.30    | 14.47 | 0.05   | 13.67 | 0.05   | 12.97 | 0.06       |
| 0301-243 | 47750.50    | 12.90 |        |       |       |       |            |
| 0323+022 | 44933.50    | 14.36 | 0.04   | 13.69 | 0.04   | 13.16 | 0.04       |
| 0323+022 | 46439.50    | 13.32 | 0.12   |       |       |       |            |
| 0323+022 | 46644.50    | 14.24 | 0.07   |       |       |       |            |
| 0323+022 | 47170.10    | 14.57 | 0.05   | 13.92 | 0.06   | 13.32 | 0.04       |
| 0323+022 | 47749.40    | 14.63 | 0.09   | 13.81 | 0.06   | 13.46 | 0.06       |
| 0323+022 | 47750.50    | 13.40 |        |       |       |       |            |
| 0336-019 | 44954.50    | 15.45 | 0.25   | 15.00 | 0.20   | 14.57 | 0.15       |
| 0336-019 | 44951.50    | 15.90 | 0.20   | 14.97 | 0.22   |       |            |
| 0336-019 | 44955.50    | 15.96 | 0.12   | 14.99 | 0.25   |       |            |
| 0336-019 | 46648.50    | 15.28 | 0.19   |       |       |       |            |
| 0406+121 | 43747.50    | 13.84 | 0.22   |       |       |       |            |
| 0406+121 | 43749.50    | 15.25 | 0.13   | 14.18 | 0.13   |       |            |
| 0406+121 | 43763.50    | 16.00 | 0.36   | 14.30 | 0.18   |       |            |
| 0406+121 | 43915.50    | 17.38 | 0.45   | 15.87 | 0.20   | 14.88 | 0.13       |
| 0406+121 | 43941.50    | 15.62 |        |       |       |       |            |
| 0406+121 | 44467.50    | 17.28 | 0.05   | 16.15 | 0.05   | 15.17 | 0.05       |
| 0420-014 | 45398.50    | 14.16 | 0.03   | 13.32 | 0.05   | 12.37 | 0.03       |
| Name    | JD 2400000+ | J    | Δ J  | H    | Δ H  | K    | Δ K  |
|---------|-------------|------|------|------|------|------|------|
| 0420-014| 45736.50    | 16.03| 0.07 | 15.48| 0.09 | 14.41| 0.04 |
| 0420-014| 45934.50    | 14.07| 0.09 |
| 0420-014| 46764.50    | 13.57| 0.06 | 12.60| 0.03 | 11.80| 0.04 |
| 0420-014| 49311.50    | 15.18| 0.03 | 14.26| 0.05 | 13.64| 0.05 |
| 0422+004| 44559.50    | 14.28| 0.02 | 13.36| 0.02 | 12.45| 0.02 |
| 0422+004| 44590.50    | 13.38| 0.31 | 12.84| 0.11 | 12.04| 0.08 |
| 0422+004| 44591.50    |      |      |      |      |      |      |
| 0422+004| 44592.50    | 14.03| 0.10 | 13.16| 0.10 | 12.26| 0.10 |
| 0422+004| 44652.50    | 13.85| 0.10 | 13.09| 0.10 | 12.21| 0.10 |
| 0422+004| 44951.50    | 14.50| 0.10 | 13.80| 0.07 | 12.99| 0.08 |
| 0422+004| 44955.50    | 14.09| 0.70 | 13.20| 0.07 | 12.30| 0.07 |
| 0422+004| 45343.50    | 13.14| 0.03 | 12.30| 0.02 | 11.49| 0.03 |
| 0422+004| 45347.50    | 13.49| 0.04 | 12.64| 0.03 | 11.79| 0.02 |
| 0422+004| 45758.50    | 15.35| 0.07 | 14.58| 0.05 |
| 0422+004| 46112.50    | 12.81| 0.03 | 12.00| 0.06 | 11.15| 0.03 |
| 0422+004| 46377.56    | 13.91| 0.16 | 13.00| 0.06 | 12.21| 0.09 |
| 0422+004| 46474.36    | 13.50| 0.07 | 12.56| 0.05 | 11.71| 0.04 |
| 0422+004| 46766.47    | 13.79| 0.04 | 12.88| 0.04 | 12.11| 0.05 |
| 0422+004| 46767.46    | 13.92| 0.07 | 13.04| 0.06 | 11.97| 0.06 |
| 0422+004| 46769.48    | 13.44| 0.09 | 12.57| 0.03 | 11.72| 0.03 |
| 0422+004| 46770.48    | 13.50| 0.06 | 12.49| 0.04 | 11.61| 0.04 |
| 0422+004| 46804.10    | 13.42| 0.08 | 12.53| 0.02 | 11.64| 0.02 |
| 0422+004| 47150.37    | 13.64| 0.08 | 12.82| 0.07 | 11.99| 0.06 |
| 0422+004| 47170.2     | 13.19| 0.05 | 12.37| 0.08 | 11.52| 0.03 |
| 0422+004| 47171.1     | 13.18| 0.05 | 12.36| 0.02 | 11.52| 0.05 |
| 0422+004| 47172.1     | 13.11| 0.08 | 12.28| 0.07 | 11.41| 0.04 |
| 0422+004| 47208.50    | 12.89| 0.04 |
Table 1—Continued

| Name          | JD 2400000+ | J   | Δ J | H   | Δ H | K   | Δ K |
|---------------|-------------|-----|-----|-----|-----|-----|-----|
| 0422+004      | 47210.50    | 12.85 | 0.16 | 12.00 | 0.11 |
| 0422+004      | 47377.4     | 14.05 | 0.04 | 13.23 | 0.04 | 12.33 | 0.04 |
| 0422+004      | 47378.4     | 14.01 | 0.03 | 13.22 | 0.04 | 12.29 | 0.04 |
| 0422+004      | 47571.0     | 13.50 | 0.13 | 12.65 | 0.13 | 11.79 | 0.11 |
| 0422+004      | 48558.58    | 13.63 | 0.26 | 12.84 | 0.12 | 12.04 | 0.07 |
| 0422+004      | 48607.41    | 13.47 | 0.07 | 12.69 | 0.03 | 11.91 | 0.03 |
| 0422+004      | 48642.57    | 13.77 | 0.15 | 13.13 | 0.14 | 12.28 | 0.10 |
| 0422+004      | 48882.80    | 13.17 | 0.15 | 12.57 | 0.08 | 11.84 | 0.06 |
| 0422+004      | 48884.78    | 13.17 | 0.12 | 12.46 | 0.05 | 11.71 | 0.05 |
| 0422+004      | 48928.55    | 13.11 | 0.04 | 12.27 | 0.04 | 11.57 | 0.03 |
| 0422+004      | 48931.65    | 13.22 | 0.21 | 12.17 | 0.05 | 11.42 | 0.05 |
| 0521-365      | 41925.00    |       |      |      |      |      |      |
| 0521-365      | 41961.00    | 12.10 | 0.30 | 10.80 | 0.20 |
| 0521-365      | 43021.00    | 11.75 | 0.09 | 11.02 | 0.08 |
| 0521-365      | 43148.00    |       |      |      |      |      |      |
| 0521-365      | 43425.00    | 12.50 | 0.17 | 12.05 | 0.10 | 11.43 | 0.11 |
| 0521-365      | 43523.00    | 13.00 | 0.09 | 12.05 | 0.06 | 11.52 | 0.08 |
| 0521-365      | 43602.00    | 13.00 | 0.09 | 12.05 | 0.06 | 11.30 | 0.14 |
| 0521-365      | 43883.00    | 12.98 | 0.04 | 12.09 | 0.03 | 11.30 | 0.03 |
| 0521-365      | 44083.00    | 12.84 | 0.04 | 12.00 | 0.02 | 11.32 | 0.03 |
| 0521-365      | 44172.00    | 12.84 | 0.04 | 12.12 | 0.04 | 11.47 | 0.01 |
| 0521-365      | 44203.00    | 12.88 | 0.05 | 12.15 | 0.02 | 11.47 | 0.03 |
| 0521-365      | 44275.00    | 12.98 |      | 12.16 |      | 11.48 |
| 0521-365      | 44453.00    | 13.07 |      | 12.39 |      | 11.54 |
| 0521-365      | 44467.50    | 13.07 | 0.02 | 12.22 | 0.02 | 11.54 | 0.02 |
| 0521-365      | 44495.00    | 13.24 |      | 12.06 |      | 11.85 |
| 0521-365      | 45931.50    | 12.64 | 0.10 |      |      |      |      |
Table 1—Continued

| Name     | JD 2400000+ | J   | Δ J | H   | Δ H | K   | Δ K |
|----------|-------------|-----|-----|-----|-----|-----|-----|
| 0521-365 | 46803.2     | 12.89 | 0.02 | 12.10 | 0.04 | 11.41 | 0.04 |
| 0521-365 | 47168.2     | 12.80 | 0.06 | 12.03 | 0.01 | 11.34 | 0.05 |
| 0521-365 | 47378.4     | 12.81 | 0.06 | 12.08 | 0.03 | 11.41 | 0.03 |
| 0548-322 | 43435.00    |     |   |     |     | 12.17 | 0.13 |
| 0548-322 | 43602.00    | 13.56 | 0.09 | 12.81 | 0.06 | 12.28 | 0.05 |
| 0548-322 | 43888.00    | 13.60 | 0.06 | 13.05 | 0.06 | 12.44 | 0.06 |
| 0548-322 | 44175.00    | 13.65 | 0.06 | 12.86 | 0.05 | 12.53 | 0.06 |
| 0548-322 | 44203.00    | 13.56 | 0.12 | 12.89 | 0.03 | 12.35 | 0.05 |
| 0548-322 | 44274.00    | 13.76 |      | 13.05          |      | 12.54          |
| 0548-322 | 44453.00    | 13.91 | 0.02 | 13.13 | 0.02 | 12.67 | 0.02 |
| 0548-322 | 44505.00    | 13.96 |      | 13.07          |      | 12.72          |
| 0548-322 | 44527.50    |     |   |     |     | 12.99 | 0.11 |
| 0548-322 | 46804.3     | 13.75 | 0.04 | 13.01 | 0.03 | 12.56 | 0.02 |
| 0548-322 | 47170.2     | 13.63 | 0.11 | 12.94 | 0.03 | 12.47 | 0.04 |
| 0716+332 | 46505.50    | 12.93 | 0.03 | 12.18 | 0.05 | 11.37 | 0.04 |
| 0716+332 | 46506.50    | 12.86 | 0.04 | 12.10 | 0.03 | 11.30 | 0.02 |
| 0716+332 | 46763.50    |     |   |     |     | 14.15 | 0.08 |
| 0716+332 | 46849.50    | 14.92 | 0.14 | 14.09 | 0.10 | 13.31 | 0.09 |
| 0736+017 | 44592.50    | 15.22 | 0.15 | 14.24 | 0.15 | 13.65 | 0.13 |
| 0736+017 | 44951.50    | 14.61 | 0.10 | 13.95 | 0.10 | 13.04 | 0.07 |
| 0736+017 | 44955.50    | 14.38 | 0.08 | 13.56 | 0.06 | 12.60 | 0.06 |
| 0736+017 | 45311.50    |     |   |     |     | 13.97 | 0.10 |
| 0736+017 | 45345.50    | 14.19 | 0.03 | 13.32 | 0.02 | 12.43 | 0.02 |
| 0736+017 | 45399.50    | 14.55 | 0.05 | 13.53 | 0.09 | 12.51 | 0.07 |
| 0736+017 | 45733.50    | 14.46 | 0.04 | 13.53 | 0.03 | 12.67 | 0.02 |
| 0736+017 | 45810.50    | 14.09 | 0.03 | 13.21 | 0.04 | 12.22 | 0.03 |
| 0736+017 | 46033.50    | 13.73 | 0.04 | 12.68 | 0.10 | 11.68 | 0.03 |
Table 1—Continued

| Name   | JD 2400000+ | J   | Δ J | H   | Δ H | K   | Δ K |
|--------|-------------|-----|-----|-----|-----|-----|-----|
| 0736+017 | 46037.50    | 14.33 | 0.17 | 13.14 | 0.10 | 11.98 | 0.08 |
| 0736+017 | 46481.50    | 14.30 | 0.04 | 13.44 | 0.05 | 12.43 | 0.05 |
| 0736+017 | 47207.50    | 14.66 | 0.03 |        |     |       |     |
| 0736+017 | 47208.50    | 14.68 | 0.05 |        |     |       |     |
| 0736+017 | 48176.50    |       |      |        |     | 12.63 | 0.04 |
| 0736+017 | 49311.50    | 13.00 | 0.03 | 12.21 | 0.03 | 11.32 | 0.03 |
| 0823-22  | 44559.50    | 13.90 | 0.02 | 13.04 | 0.02 | 12.20 | 0.02 |
| 0823-22  | 44594.50    | 15.30 | 0.15 | 14.84 | 0.20 | 14.16 | 0.11 |
| 0823-22  | 44951.50    | 13.91 | 0.08 | 13.24 | 0.06 | 12.79 | 0.08 |
| 0823-22  | 44955.50    | 13.92 | 0.07 | 13.12 | 0.06 | 12.51 | 0.07 |
| 0823-22  | 47168.50    |       |      |        |     | 12.00 |     |
| 0823-22  | 47169.3     | 13.42 | 0.09 | 12.68 | 0.05 | 11.92 | 0.07 |
| 0823-22  | 47570.2     | 13.92 | 0.08 | 13.21 | 0.04 | 12.36 | 0.05 |
| 0912+297 | 44351.50    |       |      |        |     | 13.82 | 0.04 |
| 0912+297 | 44701.50    |       |      |        |     | 12.22 | 0.03 |
| 0912+297 | 44702.50    | 14.00 | 0.06 | 13.39 | 0.08 | 12.48 | 0.05 |
| 0912+297 | 44703.50    | 14.06 | 0.03 | 13.25 | 0.07 | 12.40 | 0.03 |
| 0912+297 | 45347.50    | 13.66 | 0.04 | 12.96 | 0.02 | 12.26 | 0.03 |
| 0912+297 | 45758.50    |       |      |        |     | 15.33 | 0.05 |
| 1034-293 | 44559.50    | 14.66 | 0.02 | 13.69 | 0.02 | 12.71 | 0.02 |
| 1034-293 | 44594.50    | 14.62 | 0.13 | 13.61 | 0.10 |        |     |
| 1034-293 | 44654.50    | 14.56 | 0.10 | 13.61 | 0.10 | 12.49 | 0.10 |
| 1034-293 | 44771.50    | 14.44 | 0.15 | 13.45 | 0.13 | 12.36 | 0.10 |
| 1034-293 | 44951.50    | 15.02 | 0.14 | 13.92 | 0.07 | 13.31 | 0.11 |
| 1055+018 | 44951.50    | 15.10 | 0.11 | 14.44 | 0.08 | 13.28 | 0.10 |
| 1055+018 | 47571.34    | 14.99 | 0.37 | 14.00 | 0.41 | 13.15 | 0.36 |
| 1156+295 | 44699.50    |       |      |        |     | 11.09 | 0.02 |
|          |             |      |      |        |     | 10.22 | 0.02 |
Table 1—Continued

| Name   | JD 2400000+ | J   | Δ J | H   | Δ H | K   | Δ K |
|--------|-------------|-----|-----|-----|-----|-----|-----|
| 1156+295 | 44700.50    | 11.30 | 0.03 | 9.87 | 0.02 |
| 1156+295 | 44701.50    | 12.14 | 0.03 | 11.35 | 0.02 | 10.53 | 0.02 |
| 1156+295 | 44702.50    | 11.98 | 0.03 | 11.16 | 0.02 | 10.31 | 0.02 |
| 1156+295 | 44703.50    | 12.26 | 0.03 | 11.49 | 0.02 | 10.76 | 0.02 |
| 1156+295 | 44706.50    | 12.46 | 0.08 | 11.67 | 0.08 | 10.84 | 0.08 |
| 1156+295 | 44725.50    | 14.05 | 0.04 | 13.07 | 0.03 | 12.21 | 0.03 |
| 1156+295 | 44727.50    | 13.60 | 0.03 | 12.69 | 0.03 | 11.86 | 0.03 |
| 1156+295 | 44728.50    | 13.45 | 0.03 | 12.46 | 0.03 | 11.66 | 0.04 |
| 1156+295 | 44729.50    | 13.95 | 0.04 | 12.98 | 0.03 | 12.09 | 0.02 |
| 1156+295 | 45054.50    | 13.32 | 0.03 | 12.46 | 0.01 | 11.52 | 0.03 |
| 1156+295 | 45090.50    | 12.39 | 0.07 | 11.69 | 0.07 | 10.84 | 0.06 |
| 1156+295 | 45091.50    | 12.85 | 0.09 | 12.01 | 0.09 | 11.02 | 0.09 |
| 1156+295 | 45310.50    | 12.06 | 0.10 |
| 1156+295 | 45311.50    | 11.88 | 0.10 |
| 1156+295 | 45336.50    | 13.54 | 0.10 |
| 1156+295 | 45344.50    | 14.82 | 0.06 | 13.98 | 0.04 | 13.12 | 0.03 |
| 1156+295 | 45443.50    | 15.77 | 0.07 | 14.83 | 0.08 | 13.78 | 0.07 |
| 1156+295 | 45860.50    | 12.30 | 0.10 | 11.45 | 0.10 | 10.56 | 0.10 |
| 1156+295 | 45861.50    | 12.37 | 0.10 | 11.32 | 0.10 | 10.53 | 0.10 |
| 1156+295 | 45862.50    | 12.44 | 0.10 | 11.55 | 0.10 | 10.61 | 0.10 |
| 1156+295 | 45863.50    | 12.23 | 0.10 | 11.34 | 0.10 | 10.45 | 0.10 |
| 1156+295 | 45865.50    | 12.11 | 0.10 | 11.27 | 0.10 | 10.38 | 0.10 |
| 1156+295 | 45866.50    | 11.92 | 0.10 | 11.05 | 0.10 | 10.10 | 0.10 |
| 1156+295 | 46112.50    | 12.59 | 0.03 | 11.85 | 0.02 | 10.80 | 0.03 |
| 1156+295 | 46210.50    | 12.06 | 0.04 | 11.24 | 0.02 | 10.37 | 0.02 |
| 1156+295 | 46884.50    | 15.35 | 0.03 | 14.65 | 0.08 | 13.64 | 0.05 |
| 1156+295 | 46936.50    | 15.70 | 0.04 | 14.91 | 0.10 | 13.90 | 0.24 |
Table 1—Continued

| Name   | JD 2400000+ | J  | Δ J | H  | Δ H | K  | Δ K |
|--------|-------------|----|-----|----|-----|----|-----|
| 1156+295 | 46950.50    | 15.61 | 0.04 | 14.79 | 0.04 | 13.79 | 0.05 |
| 1156+295 | 46974.50    | 15.48 | 0.03 | 14.63 | 0.03 | 13.64 | 0.05 |
| 1156+295 | 47207.50    |      |      | 14.15 |     |      |     |
| 1156+295 | 47208.50    |      |      | 14.09 |     |      |     |
| 1156+295 | 47209.50    |      |      | 14.14 |     |      |     |
| 1156+295 | 47215.50    | 15.15 | 0.08 | 14.44 | 0.06 | 13.31 | 0.04 |
| 1156+295 | 47258.50    | 15.07 | 0.04 | 14.16 | 0.05 | 13.35 | 0.04 |
| 1156+295 | 49311.50    | 13.27 | 0.03 | 12.58 | 0.03 | 11.80 | 0.04 |
| 1218+304 | 43979.50    | 14.12 | 0.08 | 13.54 | 0.08 | 12.90 | 0.05 |
| 1218+304 | 44682.50    |      |      |      |     |      |     |
| 1218+304 | 44735.50    | 14.37 | 0.16 | 13.67 | 0.25 |
| 1218+304 | 46112.50    | 14.55 | 0.19 | 13.78 | 0.12 | 12.76 | 0.09 |
| 1244-255 | 44773.50    | 15.47 | 0.13 | 14.95 | 0.11 | 13.90 | 0.13 |
| 1244-255 | 44955.50    | 15.52 | 0.12 | 14.44 | 0.08 | 13.99 | 0.10 |
| 1244-255 | 47573.34    | 15.11 | 0.10 | 14.14 | 0.05 | 13.12 | 0.06 |
| 1253-055 | 42793.50    | 12.19 | 0.08 | 11.67 | 0.08 | 10.87 | 0.12 |
| 1253-055 | 42847.50    | 13.93 | 0.18 | 13.31 | 0.11 | 12.00 | 0.05 |
| 1253-055 | 42869.50    |      |      |      |     |      |     |
| 1253-055 | 42900.50    |      |      |      |     |      |     |
| 1253-055 | 42934.50    | 13.07 | 0.20 | 12.37 | 0.37 |
| 1253-055 | 42945.50    | 15.25 | 0.15 | 14.15 | 0.12 | 13.13 | 0.10 |
| 1253-055 | 42957.50    |      |      |      |     |      |     |
| 1253-055 | 43225.50    | 12.45 | 0.12 | 11.57 | 0.08 | 10.63 | 0.05 |
| 1253-055 | 43285.50    | 13.44 | 0.24 | 12.09 | 0.15 | 11.11 | 0.06 |
| 1253-055 | 43316.50    | 13.29 | 0.11 | 12.97 | 0.14 | 11.85 | 0.11 |
| 1253-055 | 44594.50    | 15.34 | 0.15 | 14.45 | 0.15 | 13.72 | 0.15 |
| 1253-055 | 44701.50    |      |      |      |     |      |     |
Table 1—Continued

| Name  | JD 2400000+ | J  | ∆ J | H  | ∆ H | K  | ∆ K |
|-------|-------------|----|-----|----|-----|----|-----|
| 1253-055 | 44702.50    | 13.65 | 0.06 |    |     |    |     |
| 1253-055 | 44703.50    | 13.56 | 0.06 | 12.50 | 0.04 |    |     |
| 1253-055 | 44728.50    | 15.70 | 0.27 | 14.40 | 0.19 | 13.73 | 0.22 |
| 1253-055 | 44729.50    | 15.26 | 0.18 | 14.28 | 0.06 | 13.44 | 0.08 |
| 1253-055 | 44773.50    | 13.57 | 0.60 | 12.65 | 0.06 | 11.81 | 0.06 |
| 1253-055 | 44955.50    | 14.84 | 0.08 | 13.77 | 0.07 | 12.80 | 0.07 |
| 1253-055 | 45346.50    | 14.82 | 0.06 | 13.98 | 0.04 | 13.00 | 0.03 |
| 1253-055 | 45370.50    | 14.60 | 0.05 | 13.62 | 0.06 | 12.71 | 0.04 |
| 1253-055 | 45424.50    | 15.70 | 0.04 | 14.54 | 0.06 | 13.62 | 0.05 |
| 1253-055 | 45515.50    |     |     |     |     |     |     |
| 1253-055 | 45735.50    | 15.09 | 0.08 | 14.07 | 0.05 | 13.18 | 0.03 |
| 1253-055 | 45810.50    | 14.88 | 0.06 | 13.82 | 0.04 | 12.95 | 0.05 |
| 1253-055 | 46033.50    | 14.38 | 0.04 | 13.44 | 0.11 | 12.37 | 0.06 |
| 1253-055 | 46119.50    | 14.55 | 0.05 | 13.65 | 0.06 | 12.53 | 0.05 |
| 1253-055 | 46180.50    | 15.46 | 0.11 | 14.07 | 0.05 | 13.09 | 0.06 |
| 1253-055 | 46229.50    | 14.82 | 0.06 | 13.82 | 0.04 | 12.78 | 0.05 |
| 1253-055 | 46231.50    | 14.60 | 0.05 | 13.59 | 0.06 | 12.57 | 0.06 |
| 1253-055 | 46484.50    | 14.70 | 0.11 | 13.78 | 0.04 | 12.82 | 0.12 |
| 1253-055 | 46644.50    |     |     |     |     |     |     |
| 1253-055 | 46645.50    | 12.42 | 0.08 | 11.55 | 0.06 |    |     |
| 1253-055 | 46647.50    | 12.40 | 0.08 | 11.63 | 0.03 |    |     |
| 1253-055 | 46648.50    | 12.59 | 0.05 | 11.74 | 0.05 |    |     |
| 1253-055 | 46649.50    | 12.81 | 0.05 | 11.99 | 0.04 |    |     |
| 1253-055 | 46782.50    | 13.42 | 0.06 | 12.41 | 0.06 | 11.46 | 0.04 |
| 1253-055 | 46787.50    | 13.62 | 0.04 | 12.70 | 0.04 | 11.74 | 0.03 |
| 1253-055 | 46852.50    | 12.97 | 0.03 | 12.10 | 0.03 | 11.16 | 0.03 |
| 1253-055 | 46884.50    | 13.83 | 0.02 | 12.81 | 0.04 | 11.77 | 0.03 |
Table 1—Continued

| Name  | JD 2400000+ | J   | Δ J | H   | Δ H | K   | Δ K |
|-------|-------------|-----|-----|-----|-----|-----|-----|
| 1253-055 | 46896.50    | 14.44 | 0.04 | 13.38 | 0.02 | 12.47 | 0.03 |
| 1253-055 | 46936.50    | 13.30 | 0.03 | 12.37 | 0.03 | 11.39 | 0.03 |
| 1253-055 | 46947.50    | 13.28 | 0.01 | 12.32 | 0.01 |
| 1253-055 | 46948.50    | 13.45 | 0.04 | 12.47 | 0.01 |
| 1253-055 | 46950.50    | 13.90 | 0.02 | 13.00 | 0.03 | 11.99 | 0.03 |
| 1253-055 | 46975.50    | 13.50 | 0.03 | 12.59 | 0.04 | 11.58 | 0.04 |
| 1253-055 | 47005.50    | 13.29 | 0.10 | 12.21 | 0.10 | 11.21 | 0.10 |
| 1253-055 | 47190.50    | 11.19 | 0.03 | 10.32 | 0.03 | 9.44  | 0.03 |
| 1253-055 | 47191.50    |       |     |       |     | 9.28  |     |
| 1253-055 | 47208.50    | 11.42 | 0.05 |
| 1253-055 | 47209.50    | 11.43 | 0.02 |
| 1253-055 | 47210.50    | 11.31 | 0.02 |
| 1253-055 | 47215.50    | 11.57 | 0.03 | 10.65 | 0.03 | 9.75  | 0.03 |
| 1253-055 | 47221.50    | 11.48 | 0.03 | 10.65 | 0.03 | 9.77  | 0.03 |
| 1253-055 | 47224.50    | 11.22 | 0.03 | 10.38 | 0.03 | 9.50  | 0.03 |
| 1253-055 | 47226.50    | 11.36 | 0.03 | 10.43 | 0.03 | 9.55  | 0.03 |
| 1253-055 | 47229.50    | 11.54 | 0.03 | 10.64 | 0.03 | 9.67  | 0.03 |
| 1253-055 | 47230.50    | 11.45 | 0.04 | 10.54 | 0.03 | 9.63  | 0.03 |
| 1253-055 | 47231.50    | 11.42 | 0.05 | 10.50 | 0.03 | 9.56  | 0.03 |
| 1253-055 | 47232.50    | 11.26 | 0.03 |
| 1253-055 | 47232.50    | 11.45 | 0.03 | 10.57 | 0.03 | 9.66  | 0.03 |
| 1253-055 | 47233.50    | 11.40 | 0.03 | 10.50 | 0.03 | 9.60  | 0.03 |
| 1253-055 | 47248.50    | 11.88 | 0.06 | 11.00 | 0.04 | 10.08 | 0.04 |
| 1253-055 | 47249.50    | 12.17 | 0.03 | 11.32 | 0.03 | 10.30 | 0.03 |
| 1253-055 | 47250.50    | 12.07 | 0.03 | 11.17 | 0.03 | 10.22 | 0.03 |
| 1253-055 | 47258.50    | 11.87 | 0.03 | 11.00 | 0.03 | 10.11 | 0.03 |
| 1253-055 | 47260.50    | 12.00 | 0.03 | 11.12 | 0.03 | 10.20 | 0.03 |
Table 1—Continued

| Name  | JD 2400000+ | J   | ∆ J | H   | ∆ H | K   | ∆ K |
|-------|-------------|-----|-----|-----|-----|-----|-----|
| 1253-055 | 47278.50   | 11.51 | 0.03 | 10.68 | 0.03 | 9.81 | 0.03 |
| 1253-055 | 47293.50   | 11.68 | 0.03 | 10.79 | 0.03 | 9.97 | 0.03 |
| 1253-055 | 47302.50   | 11.93 | 0.03 | 11.09 | 0.03 | 10.20 | 0.03 |
| 1253-055 | 47308.50   | 11.68 | 0.03 | 10.78 | 0.03 | 9.97 | 0.03 |
| 1253-055 | 47317.50   | 11.77 | 0.03 | 10.89 | 0.03 | 10.04 | 0.03 |
| 1253-055 | 47333.50   | 11.97 | 0.03 | 11.13 | 0.03 | 10.26 | 0.03 |
| 1253-055 | 47523.50   | 13.34 | 0.03 | 12.38 | 0.03 | 11.40 | 0.03 |
| 1253-055 | 47536.50   | 12.63 | 0.06 | 11.43 | 0.03 | 10.60 | 0.02 |
| 1253-055 | 47549.50   |       |     |     |     | 10.72 | 0.06 |
| 1253-055 | 47573.50   | 12.53 | 0.03 | 11.53 | 0.03 | 10.60 | 0.03 |
| 1253-055 | 47669.50   | 12.43 | 0.03 | 11.52 | 0.03 | 10.83 | 0.03 |
| 1253-055 | 47674.50   |       |     |     |     | 10.14 |     |
| 1253-055 | 47682.50   |       |     |     |     | 10.61 |     |
| Name    | JD 2400000+ | J  | Δ J | H  | Δ H | K  | Δ K |
|---------|-------------|----|-----|----|-----|----|-----|
| 1253-055 | 48636.50    | 13.23 | 0.03 | 12.27 | 0.03 | 11.30 | 0.03 |
| 1253-055 | 48651.50    | 13.53 | 0.04 | 12.47 | 0.03 | 11.48 | 0.03 |
| 1253-055 | 48741.50    | 13.48 | 0.03 | 12.48 | 0.03 | 11.49 | 0.03 |
| 1253-055 | 49029.50    | 14.88 | 0.06 | 13.94 | 0.04 | 12.93 | 0.02 |
| 1253-055 | 49105.50    | 13.62 | 0.04 | 12.65 | 0.04 | 11.66 | 0.03 |
| 1253-055 | 49133.50    | 13.98 | 0.03 | 12.93 | 0.03 | 11.86 | 0.04 |
| 1253-055 | 49134.50    | 13.98 | 0.03 | 12.95 | 0.03 | 11.88 | 0.03 |
| 1253-055 | 49162.50    | 14.61 | 0.05 | 13.51 | 0.03 | 12.56 | 0.04 |
| 1253-055 | 49163.50    | 14.40 | 0.12 | 13.48 | 0.11 | 12.49 | 0.10 |
| 1510-089 | 43029.00    |      |      |      |      | 12.29 | 0.31 |
| 1510-089 | 43279.50    | 15.23 | 0.15 | 14.08 | 0.10 | 13.00 | 0.07 |
| 1510-089 | 43602.00    |      |      |      |      | 13.82 | 0.14 |
| 1510-089 | 43683.00    |      |      |      |      | 14.03 | 0.20 |
| 1510-089 | 4400        | 15.12 | 0.20 | 14.03 | 0.07 | 13.02 | 0.06 |
| 1510-089 | 44317.00    | 14.65 | 0.19 | 13.52 | 0.08 | 12.47 | 0.06 |
| 1510-089 | 44734.50    | 14.35 | 0.12 | 13.12 | 0.05 | 11.84 | 0.06 |
| 1510-089 | 45443.50    |      |      |      |      | 13.09 | 0.09 |
| 1510-089 | 46149.50    |      |      |      |      | 12.94 | 0.20 |
| 1510-089 | 46644.50    | 14.19 | 0.06 |      |      |      |      |
| 1510-089 | 47266.50    |      |      |      |      | 12.10 |      |
| 1641+399 | 43279.50    | 14.60 | 0.10 | 13.65 | 0.10 | 12.66 | 0.08 |
| 1641+399 | 44431.50    |      |      |      |      | 12.41 | 0.03 |
| 1641+399 | 44700.50    |      |      |      |      | 11.32 | 0.04 |
| 1641+399 | 44701.50    |      |      |      |      | 11.26 | 0.03 |
| 1641+399 | 44702.50    | 13.18 | 0.03 | 12.30 | 0.02 | 11.30 | 0.04 |
| 1641+399 | 44703.50    | 13.10 | 0.02 | 12.22 | 0.03 | 11.18 | 0.03 |
| 1641+399 | 44725.50    | 12.55 | 0.06 | 11.52 | 0.04 |      |      |
Table 1—Continued

| Name   | JD 2400000+ | J     | Δ J   | H     | Δ H   | K     | Δ K   |
|--------|-------------|-------|-------|-------|-------|-------|-------|
| 1641+399 | 44726.50    | 12.61 | 0.05  | 11.54 | 0.03  |       |       |
| 1641+399 | 44727.50    | 13.71 | 0.02  | 12.72 | 0.03  | 11.64 | 0.03  |
| 1641+399 | 44728.50    |       |       |       |       | 11.91 | 0.16  |
| 1641+399 | 44729.50    | 14.06 | 0.03  | 13.17 | 0.04  | 12.08 | 0.06  |
| 1641+399 | 45252.50    | 12.28 |       | 11.41 | 0.01  | 10.38 |       |
| 1641+399 | 45274.50    | 12.77 |       | 11.84 |       | 10.81 |       |
| 1641+399 | 45370.50    | 13.14 | 0.03  | 12.19 | 0.03  | 11.29 | 0.05  |
| 1641+399 | 45424.50    | 13.40 | 0.05  | 12.37 | 0.06  | 11.47 | 0.05  |
| 1641+399 | 45428.50    | 13.40 |       | 12.37 |       | 11.48 |       |
| 1641+399 | 45433.50    | 12.60 | 0.02  | 11.86 | 0.01  | 11.03 | 0.01  |
| 1641+399 | 45443.50    | 13.24 | 0.07  | 12.30 | 0.07  | 11.31 | 0.09  |
| 1641+399 | 45447.50    | 13.20 |       | 12.31 |       | 11.30 |       |
| 1641+399 | 45476.50    | 13.19 |       | 12.30 |       | 11.26 |       |
| 1641+399 | 45595.50    | 13.82 | 0.05  | 12.82 | 0.04  | 11.87 | 0.04  |
| 1641+399 | 45607.50    | 14.20 | 0.04  | 13.32 | 0.04  | 12.68 | 0.04  |
| 1641+399 | 45626.50    | 13.93 |       | 13.05 |       | 12.04 |       |
| 1641+399 | 45735.50    | 14.50 | 0.05  | 13.44 | 0.03  | 12.51 | 0.04  |
| 1641+399 | 45768.50    | 14.46 | 0.04  | 13.53 | 0.06  | 12.61 | 0.06  |
| 1641+399 | 45811.50    | 14.30 | 0.07  | 13.39 | 0.08  | 12.43 | 0.07  |
| 1641+399 | 45840.50    | 14.19 | 0.07  | 13.25 | 0.04  | 12.37 | 0.05  |
| 1641+399 | 45915.50    | 13.58 | 0.02  | 12.70 | 0.05  | 11.76 | 0.03  |
| 1641+399 | 46112.50    |       |       |       |       | 12.49 | 0.14  |
| 1641+399 | 46148.50    |       |       |       |       | 12.55 | 0.10  |
| 1641+399 | 46180.50    | 14.65 | 0.05  | 13.75 | 0.07  | 12.71 | 0.06  |
| 1641+399 | 46216.50    | 14.53 | 0.09  | 13.71 | 0.04  | 12.57 | 0.08  |
| 1641+399 | 46238.50    | 14.60 | 0.05  | 13.71 | 0.07  | 12.71 | 0.06  |
| 1641+399 | 46484.50    | 14.26 | 0.07  | 13.32 | 0.05  | 12.32 | 0.06  |
Table 1—Continued

| Name   | JD 2400000+ | J     | \(\Delta J\) | H     | \(\Delta H\) | K     | \(\Delta K\) |
|--------|-------------|-------|---------------|-------|---------------|-------|---------------|
| 1641+399 | 46644.50    | 14.55 | 0.09          | 13.47 | 0.05          |       |               |
| 1641+399 | 46645.50    | 14.49 | 0.06          | 13.53 | 0.06          |       |               |
| 1641+399 | 46647.50    | 14.48 | 0.05          | 13.54 | 0.05          |       |               |
| 1641+399 | 46648.50    |       |               | 13.53 | 0.05          | 12.30 | 0.10          |
| 1641+399 | 46649.50    | 14.51 | 0.05          | 13.58 | 0.05          |       |               |
| 1641+399 | 46650.50    |       |               | 13.56 | 0.05          |       |               |
| 1641+399 | 46850.50    |       |               | 12.50 | 0.08          |       |               |
| 1641+399 | 46852.50    | 14.52 | 0.04          | 13.60 | 0.03          | 12.54 | 0.03          |
| 1641+399 | 46896.50    | 14.76 | 0.05          | 13.75 | 0.03          | 12.81 | 0.02          |
| 1641+399 | 46917.50    | 14.86 | 0.13          | 13.96 | 0.09          | 12.96 | 0.05          |
| 1641+399 | 46936.50    | 14.94 | 0.06          | 14.07 | 0.05          | 13.01 | 0.03          |
| 1641+399 | 46950.50    | 15.10 | 0.03          | 14.21 | 0.05          | 13.21 | 0.03          |
| 1641+399 | 46974.50    | 15.17 | 0.03          | 14.26 | 0.05          | 13.21 | 0.03          |
| 1641+399 | 47005.50    | 15.36 | 0.05          | 14.37 | 0.05          | 13.50 | 0.05          |
| 1641+399 | 47007.50    |       |               | 14.51 | 0.05          |       |               |
| 1641+399 | 47058.50    |       |               | 14.60 | 0.10          |       |               |
| 1641+399 | 48005.50    | 15.23 | 0.17          | 14.38 | 0.12          | 13.54 | 0.13          |
| 1641+399 | 48322.50    | 13.86 | 0.02          | 13.00 | 0.03          | 12.08 | 0.03          |
| 1641+399 | 48326.50    | 14.24 | 0.41          | 13.05 | 0.14          | 12.00 | 0.09          |
| 1641+399 | 48329.50    | 13.93 | 0.06          | 13.11 | 0.09          | 12.17 | 0.06          |
| 1641+399 | 48330.50    | 13.43 | 0.14          | 13.19 | 0.12          | 12.12 | 0.13          |
| 1641+399 | 48331.50    | 14.21 | 0.13          | 13.25 | 0.04          | 12.23 | 0.04          |
| 1641+399 | 48333.50    | 14.01 | 0.11          | 13.07 | 0.07          | 12.33 | 0.05          |
| 1641+399 | 48335.50    | 14.05 | 0.15          | 13.09 | 0.09          | 12.28 | 0.08          |
| 1641+399 | 48342.50    | 14.03 | 0.04          | 13.15 | 0.02          | 12.26 | 0.01          |
| 1641+399 | 48366.50    | 14.09 | 0.03          | 13.19 | 0.10          | 12.25 | 0.08          |
| 1641+399 | 48375.50    | 14.04 | 0.18          | 13.42 | 0.15          | 12.42 | 0.04          |
| Name   | JD 2400000+ | J   | Δ J | H   | Δ H | K   | Δ K |
|--------|-------------|-----|-----|-----|-----|-----|-----|
| 1641+399 | 48424.50    | 14.56 | 0.05 | 13.63 | 0.03 | 12.86 | 0.02 |
| 1641+399 | 48447.50    | 14.56 | 0.05 | 13.66 | 0.03 | 12.75 | 0.04 |
| 1641+399 | 48477.50    | 13.80 | 0.18 | 13.00 | 0.09 | 12.00 | 0.08 |
| 1641+399 | 48478.50    | 13.60 | 0.17 | 12.97 | 0.06 | 12.02 | 0.06 |
| 1641+399 | 48479.50    | 13.51 | 0.16 | 12.82 | 0.12 | 11.94 | 0.11 |
| 1641+399 | 48481.50    | 13.94 | 0.22 | 13.12 | 0.17 | 12.20 | 0.06 |
| 1641+399 | 48482.50    | 13.38 | 0.05 | 12.75 | 0.15 | 11.94 | 0.06 |
| 1641+399 | 48485.50    | 13.63 | 0.03 | 12.69 | 0.03 | 11.94 | 0.11 |
| 1641+399 | 48486.50    | 13.63 | 0.11 | 12.82 | 0.12 | 11.83 | 0.08 |
| 1641+399 | 48498.50    | 13.67 | 0.29 | 12.69 | 0.13 | 11.69 | 0.13 |
| 1641+399 | 48738.50    | 13.16 | 0.10 | 12.30 | 0.06 | 11.41 | 0.06 |
| 1641+399 | 48739.50    | 13.02 | 0.04 | 12.29 | 0.03 | 11.35 | 0.04 |
| 1641+399 | 48740.50    | 12.97 | 0.10 | 12.27 | 0.04 | 11.33 | 0.04 |
| 1641+399 | 48741.50    | 13.07 | 0.14 | 12.18 | 0.05 | 11.33 | 0.04 |
| 1641+399 | 48741.50    | 13.13 | 0.04 | 12.27 | 0.03 | 11.38 | 0.03 |
| 1641+399 | 48743.50    | 12.89 | 0.09 | 12.14 | 0.07 | 11.29 | 0.05 |
| 1641+399 | 48769.50    | 13.10 | 0.19 | 12.45 | 0.13 | 11.51 | 0.08 |
| 1641+399 | 48771.50    | 13.23 | 0.13 | 12.55 | 0.06 | 11.86 | 0.04 |
| 1641+399 | 48881.50    |     |     |     |     | 12.23 | 0.24 |
| 1641+399 | 48922.50    |     |     |     |     | 12.61 | 0.29 |
| 1641+399 | 49133.50    | 15.03 | 0.03 | 14.02 | 0.04 | 13.09 | 0.03 |
| 1641+399 | 49246.50    | 15.48 | 0.03 | 14.58 | 0.07 | 13.59 | 0.05 |
| 1717+178 | 44467.50    | 15.14 | 0.02 | 14.22 | 0.02 | 13.24 | 0.02 |
| 1717+178 | 46649.50    |     |     |     |     | 14.24 | 0.05 |
| 1717+178 | 46650.50    |     |     |     |     | 14.43 | 0.05 |
| 1717+178 | 47007.50    |     |     |     |     | 15.21 | 0.20 |
| 1921-293 | 44350.50    | 13.53 | 0.03 | 12.50 | 0.02 |     |     |
Table 1—Continued

| Name  | JD 2400000+ | J   | Δ J | H   | Δ H | K   | Δ K |
|-------|-------------|-----|-----|-----|-----|-----|-----|
| 1921-293 | 44351.50     |     |     |     |     |     |     |
| 1921-293 | 44430.50     |     |     |     |     |     |     |
| 1921-293 | 44467.50     | 14.92 | 0.02 | 13.92 | 0.02 | 12.95 | 0.02 |
| 1921-293 | 44725.50     | 14.42 | 0.08 | 13.53 | 0.03 | 12.61 | 0.04 |
| 1921-293 | 44726.50     | 14.42 | 0.08 | 13.47 | 0.05 | 12.38 | 0.02 |
| 1921-293 | 44727.50     | 14.30 | 0.04 | 13.42 | 0.05 | 12.45 | 0.02 |
| 1921-293 | 44729.50     | 14.19 | 0.07 | 13.23 | 0.04 | 12.29 | 0.04 |
| 1921-293 | 45224.50     | 13.34 | 0.03 | 12.29 | 0.05 | 11.38 | 0.04 |
| 1921-293 | 45226.50     | 13.24 |     | 12.05 |     | 11.27 |     |
| 1921-293 | 45552.50     | 13.82 | 0.05 | 12.79 | 0.04 | 11.91 | 0.04 |
| 1921-293 | 45915.50     | 13.68 | 0.02 | 12.68 | 0.05 | 11.70 | 0.03 |
| 1921-293 | 45932.50     |     |     | 15.09 | 0.10 |     |     |
| 1921-293 | 46646.50     |     |     | 14.77 | 0.10 |     |     |
| 1921-293 | 46649.50     |     |     | 13.31 | 0.05 |     |     |
| 1921-293 | 46650.50     |     |     | 14.07 | 0.05 |     |     |
| 1921-293 | 46896.50     | 15.00 | 0.07 | 13.98 | 0.04 | 13.06 | 0.03 |
| 1921-293 | 47004.50     | 15.40 | 0.06 |     |     |     |     |
| 1921-293 | 47377.05     | 15.35 | 0.09 | 14.55 | 0.13 | 13.51 | 0.07 |
| 1921-293 | 47753.15     | 14.53 | 0.03 | 13.62 | 0.03 | 12.72 | 0.02 |
| 1921-293 | 48447.50     | 14.22 | 0.03 | 13.23 | 0.04 | 12.31 | 0.03 |
| 1921-293 | 49246.50     | 13.83 | 0.02 | 12.92 | 0.03 | 11.98 | 0.03 |
| 2155-304 | 43863.00     | 11.78 | 0.03 | 11.23 | 0.03 | 10.59 | 0.03 |
| 2155-304 | 43999.00     | 12.11 | 0.03 | 11.51 | 0.02 | 10.82 |     |
| 2155-304 | 44079.00     | 11.54 |     | 10.92 | 0.01 | 10.25 | 0.01 |
| 2155-304 | 44430.50     | 11.64 | 0.02 | 11.04 | 0.09 | 10.56 | 0.01 |
| 2155-304 | 44431.50     |     |     | 10.55 | 0.01 |     |     |
| 2155-304 | 44432.50     |     |     | 10.46 | 0.01 |     |     |
| Name   | JD 2400000+ | J  | Δ J | H  | Δ H | K  | Δ K |
|--------|-------------|----|----|----|----|----|----|
| 2155-304 | 44453.00    | 11.78 | 11.09 | 10.48 |
| 2155-304 | 44461.50    | 11.81 | 11.32 | 10.62 | 0.03 |
| 2155-304 | 44462.50    | 11.22 | 10.53 | 0.03 |
| 2155-304 | 44463.50    | 11.81 | 11.14 | 10.47 | 0.03 |
| 2155-304 | 44505.00    | 11.76 | 10.89 | 10.27 |
| 2155-304 | 44545.00    | 11.37 | 10.73 | 10.10 |
| 2155-304 | 45564.50    | 11.84 | 11.22 | 10.60 |
| 2155-304 | 45930.50    | 11.41 | 10.74 | 10.07 | 0.10 |
| 2155-304 | 45934.50    | 11.21 | 10.64 | 10.29 | 0.10 |
| 2155-304 | 45949.50    | 11.53 | 10.91 | 10.22 |
| 2155-304 | 46013.50    | 11.47 | 10.82 | 10.19 |
| 2155-304 | 46015.50    | 11.52 | 10.87 | 10.21 |
| 2155-304 | 46644.50    | 12.17 | 11.47 | 0.05 |
| 2155-304 | 46648.50    | 12.23 | 11.37 | 0.05 |
| 2155-304 | 46649.50    | 11.46 | 0.05 |
| 2155-304 | 46650.50    | 11.97 | 0.05 |
| 2155-304 | 46803.04    | 11.21 | 10.56 | 0.02 | 9.93 | 0.04 |
| 2155-304 | 47004.50    | 11.15 | 10.61 | 0.05 | 9.97 | 0.05 |
| 2155-304 | 47376.26    | 12.31 | 11.72 | 0.03 | 11.08 | 0.03 |
| 2155-304 | 47377.3     | 12.37 | 11.77 | 0.05 | 11.16 | 0.05 |
| 2155-304 | 47378.14    | 12.40 | 11.81 | 0.03 | 11.17 | 0.05 |
| 2155-304 | 47748.11    | 12.27 | 11.66 | 0.03 | 11.02 | 0.05 |
| 2155-304 | 47749.15    | 12.26 | 11.63 | 0.02 | 11.00 | 0.03 |
| 2155-304 | 47750.16    | 12.24 | 11.65 | 0.04 | 11.00 | 0.03 |
| 2155-304 | 47751.09    | 12.26 | 11.68 | 0.04 | 11.03 | 0.05 |
| 2155-304 | 47753.16    | 12.40 | 11.77 | 0.03 | 11.12 | 0.03 |
| 2155-304 | 48575.50    | 11.28 | 10.55 | 0.03 | 9.94 | 0.03 |
Table 1—Continued

| Name   | JD 2400000+ | J   | $\Delta$ J | H   | $\Delta$ H | K   | $\Delta$ K |
|--------|-------------|-----|------------|-----|------------|-----|------------|
| 2155-304 | 48576.50    | 11.17 | 0.03      | 10.56 | 0.02      | 9.92 | 0.02      |
| 2155-304 | 48576.50    | 11.34 | 0.04      | 10.57 | 0.03      | 9.96 | 0.03      |
| 2155-304 | 48577.50    | 11.12 | 0.02      | 10.53 | 0.02      | 9.88 | 0.02      |
| 2155-304 | 48577.50    | 11.18 | 0.03      | 10.46 | 0.03      | 9.85 | 0.03      |
| 2155-304 | 48579.50    | 11.10 | 0.03      | 10.50 | 0.02      | 9.87 | 0.02      |
| 2155-304 | 48579.50    | 11.23 | 0.04      | 10.54 | 0.03      | 9.92 | 0.03      |
| 2155-304 | 48580.50    | 11.20 | 0.02      | 10.52 | 0.02      | 9.86 | 0.02      |
| 2155-304 | 48581.50    | 11.14 | 0.02      | 10.55 | 0.02      | 9.88 | 0.02      |
| 2155-304 | 48585.50    | 11.13 | 0.04      | 10.43 | 0.03      | 9.80 | 0.03      |
| 2155-304 | 48590.50    | 11.05 | 0.03      | 10.41 | 0.02      | 9.77 | 0.03      |
| 2155-304 | 48591.50    | 11.02 | 0.03      | 10.39 | 0.02      | 9.73 | 0.02      |
| 2155-304 | 48592.50    | 11.05 | 0.03      | 10.38 | 0.02      | 9.71 | 0.03      |
| 2155-304 | 49491.50    | 11.51 | 0.03      | 10.82 | 0.03      | 10.18 | 0.03    |
| 2155-304 | 49492.50    | 11.47 | 0.03      | 10.78 | 0.03      | 10.13 | 0.03    |
| 2155-304 | 49496.50    | 11.36 | 0.03      | 10.60 | 0.03      | 9.98  | 0.03    |
| 2155-304 | 49497.50    | 11.34 | 0.03      | 10.62 | 0.03      | 9.99  | 0.03    |
| 2155-304 | 49498.50    | 11.30 | 0.03      | 10.59 | 0.03      | 9.93  | 0.03    |
| 2208-137 | 45934.50    |       | 14.54     | 0.07  |           |      |          |
| 2208-137 | 46646.50    |       | 14.40     | 0.05  |           |      |          |
| 2208-137 | 46647.50    |       | 14.43     | 0.05  |           |      |          |
| 2208-137 | 46649.50    |       | 14.50     | 0.08  |           |      |          |
| 2208-137 | 46650.50    |       | 14.75     | 0.07  |           |      |          |
| 2208-137 | 47377.3     | 15.27 | 0.08      | 14.44 | 0.10      | 13.29 | 0.05    |
| 2208-137 | 47749.3     | 15.72 | 0.19      | 14.69 | 0.08      | 13.57 | 0.15    |
| 2223-052 | 39364.50    |       |           |      | 13.01     | 0.12  |          |
| 2223-052 | 39671.50    |       |           |      | 13.51     | 0.26  |          |
| 2223-052 | 39698.50    |       |           |      | 13.01     |       |          |
Table 1—Continued

| Name    | JD 2400000+ | J  | Δ J | H  | Δ H | K  | Δ K |
|---------|-------------|----|-----|----|-----|----|-----|
| 2223-052 | 39729.50    |    |     |    |     |    |     |
| 2223-052 | 39760.50    |    |     |    |     |    |     |
| 2223-052 | 40571.50    |    |     |    |     |    |     |
| 2223-052 | 40795.50    |    |     |    |     |    |     |
| 2223-052 | 40795.50    |    |     |    |     |    |     |
| 2223-052 | 41133.50    |    |     |    |     |    |     |
| 2223-052 | 41134.50    |    |     |    |     |    |     |
| 2223-052 | 41159.50    |    |     |    |     |    |     |
| 2223-052 | 41244.50    |    |     |    |     |    |     |
| 2223-052 | 41245.50    |    |     |    |     |    |     |
| 2223-052 | 43067.50    | 15.05 | 0.12 | 14.18 | 0.10 | 13.18 | 0.10 |
| 2223-052 | 43707.50    |    |     |    |     |    |     |
| 2223-052 | 44229.50    |    |     |    |     |    |     |
| 2223-052 | 44424.50    | 13.86 | 12.96 |    |    |    |    |
| 2223-052 | 44430.50    |    |     |    |     |    |     |
| 2223-052 | 44431.50    | 12.99 | 0.09 | 12.92 | 0.05 |
| 2223-052 | 44432.50    |    |     |    |     |    |     |
| 2223-052 | 44467.50    | 14.81 | 0.02 | 13.80 | 0.02 | 12.87 | 0.02 |
| 2223-052 | 44528.50    | 15.24 | 0.02 | 14.31 | 0.03 | 13.46 | 0.03 |
| 2223-052 | 44904.50    | 13.62 | 12.64 |    |    |    |    |
| 2223-052 | 45224.50    | 12.72 | 0.02 | 11.86 | 0.01 | 11.05 | 0.03 |
| 2223-052 | 45310.50    |    |     |    |     |    |     |
| 2223-052 | 45311.50    |    |     |    |     |    |     |
| 2223-052 | 45339.50    |    |     |    |     |    |     |
| 2223-052 | 45522.50    | 12.61 | 0.02 | 11.61 | 0.01 | 10.82 | 0.01 |
| 2223-052 | 45592.50    |    |     |    |     |    |     |
| 2223-052 | 45594.50    | 13.08 | 0.02 | 12.03 | 0.01 | 11.04 | 0.02 |
Table 1—Continued

| Name     | JD 2400000+ | J  | ∆ J | H   | ∆ H | K   | ∆ K |
|----------|-------------|----|-----|-----|-----|-----|-----|
| 2223-052 | 45606.50    | 13.95 | 0.03 | 12.97 | 0.02 | 12.19 | 0.03 |
| 2223-052 | 45671.50    | 12.70 | 11.78 | 10.85 |     |     |     |
| 2223-052 | 45860.50    | 14.82 | 13.78 | 12.71 |     |     |     |
| 2223-052 | 45861.50    |     |     | 12.94 | 0.10 |     |     |
| 2223-052 | 45862.50    |     |     | 13.00 | 0.10 |     |     |
| 2223-052 | 45900.50    | 15.07 | 0.03 | 13.09 | 0.03 | 13.06 | 0.03 |
| 2223-052 | 45916.50    | 15.20 | 0.02 | 14.17 | 0.05 | 13.22 | 0.03 |
| 2223-052 | 45934.50    |     |     | 14.22 | 0.11 |     |     |
| 2223-052 | 45981.50    | 15.18 |     | 14.20 |     | 13.30 |     |
| 2223-052 | 45988.50    | 15.17 | 0.03 | 13.98 | 0.04 | 13.06 | 0.03 |
| 2223-052 | 46057.50    | 15.70 | 0.14 | 14.69 | 0.08 | 13.73 | 0.05 |
| 2223-052 | 46236.50    | 15.97 | 0.05 | 14.87 | 0.10 | 13.90 | 0.06 |
| 2223-052 | 46237.50    | 15.09 | 0.03 | 14.50 | 0.07 | 13.70 | 0.05 |
| 2223-052 | 46266.50    | 16.42 |     | 15.33 |     | 14.42 |     |
| 2223-052 | 46272.50    | 16.40 |     | 15.40 |     | 14.53 |     |
| 2223-052 | 46273.50    | 16.34 |     | 15.37 |     | 14.48 |     |
| 2223-052 | 46302.50    | 16.45 | 0.27 |     |     | 14.59 | 0.12 |
| 2223-052 | 46647.50    |     |     | 15.67 | 0.15 |     |     |
| 2223-052 | 46714.50    | 16.27 | 0.22 | 15.41 | 0.16 | 14.17 | 0.08 |
| 2223-052 | 46715.50    | 15.76 | 0.14 | 14.91 | 0.10 | 14.03 | 0.07 |
| 2223-052 | 46763.50    | 14.79 | 0.14 | 13.80 | 0.10 | 12.73 | 0.10 |
| 2223-052 | 46766.50    | 14.58 | 0.11 | 13.65 | 0.08 | 12.65 | 0.08 |
| 2223-052 | 46788.50    | 14.29 | 0.04 | 13.43 | 0.03 | 12.47 | 0.03 |
| 2223-052 | 46806.50    | 13.66 | 0.04 | 12.80 | 0.03 | 11.94 | 0.03 |
| 2223-052 | 46936.50    | 14.52 | 0.04 | 13.63 | 0.03 | 12.67 | 0.04 |
| 2223-052 | 46974.50    | 15.15 | 0.03 | 14.26 | 0.05 | 13.31 | 0.04 |
| 2223-052 | 46999.50    | 15.00 | 0.03 | 14.11 | 0.05 | 13.18 | 0.03 |
Table 1—Continued

| Name    | JD 2400000+ | J  | Δ J | H  | Δ H | K  | Δ K |
|---------|-------------|----|-----|----|-----|----|-----|
| 2223-052 | 47004.50    | 15.23 | 0.04 | 14.21 | 0.05 | 13.28 | 0.03 |
| 2223-052 | 47006.50    |        | 14.29 | 0.10 |        |        |      |
| 2223-052 | 47007.50    |        | 14.34 | 0.06 |        |        |      |
| 2223-052 | 47026.50    | 14.66 | 0.05 | 13.94 | 0.04 | 13.03 | 0.03 |
| 2223-052 | 47105.50    | 14.88 | 0.06 | 13.94 | 0.04 | 13.03 | 0.03 |
| 2223-052 | 47113.50    |        | 14.21 | 0.11 |        |        |      |
| 2223-052 | 47376.31    | 13.98 | 0.03 | 13.12 | 0.04 | 12.27 | 0.04 |
| 2223-052 | 47398.50    | 14.52 | 0.04 | 13.63 | 0.03 | 12.69 | 0.04 |
| 2223-052 | 47750.15    | 14.71 | 0.04 | 13.90 | 0.06 | 12.91 | 0.05 |
| 2223-052 | 47828.50    | 14.71 | 0.05 | 13.66 | 0.03 | 12.61 | 0.04 |
| 2223-052 | 47845.50    | 14.71 | 0.05 | 13.60 | 0.03 | 12.59 | 0.04 |
| 2223-052 | 48565.50    | 16.27 | 0.04 | 15.26 | 0.14 | 14.34 | 0.09 |
| 2223-052 | 49211.50    | 15.76 | 0.14 | 14.91 | 0.10 | 14.10 | 0.07 |
| 2223-052 | 49246.50    | 16.07 | 0.04 | 15.26 | 0.14 | 14.34 | 0.09 |
| 2251+158 | 43067.50    | 14.18 | 0.15 | 13.38 | 0.12 | 12.40 | 0.07 |
| 2251+158 | 44467.50    | 14.50 | 0.02 | 13.76 | 0.02 | 12.95 | 0.02 |
| 2251+158 | 45311.50    |        |        | 13.86 | 0.10 |        |      |
| 2251+158 | 45350.50    |        |        | 14.69 | 0.08 | 13.73 | 0.05 |
| 2251+158 | 45562.50    | 14.94 | 0.07 | 14.22 | 0.05 | 13.44 | 0.04 |
| 2251+158 | 45609.50    | 14.93 | 0.03 | 14.10 | 0.01 | 13.15 | 0.01 |
| 2251+158 | 45932.50    |        |        | 14.54 | 0.07 |        |      |
| 2251+158 | 46648.50    |        |        | 14.34 | 0.09 |        |      |
| 2251+158 | 46763.50    | 14.39 | 0.10 | 13.82 | 0.08 | 12.92 | 0.08 |
| 2251+158 | 46766.50    | 14.41 | 0.10 | 13.59 | 0.07 | 12.92 | 0.05 |
| 2251+158 | 47005.50    |        |        | 14.12 | 0.07 |        |      |
| 2251+158 | 47115.50    |        |        | 13.94 | 0.11 | 13.07 | 0.11 |
| 2251+158 | 47752.23    | 14.87 | 0.05 | 14.38 | 0.03 | 13.63 | 0.06 |
Table 1—Continued

| Name     | JD 2400000+ | J  | Δ J | H  | Δ H | K  | Δ K |
|----------|-------------|----|-----|----|-----|----|-----|
| 2251+158 | 47753.29    | 14.78 | 0.04 | 14.31 | 0.04 | 13.51 | 0.03 |
| 2251+158 | 49246.50    | 14.29 | 0.04 | 13.60 | 0.03 | 12.71 | 0.04 |
| 2345-167 | 45925.50    | 15.85 | 0.10 |       |     |     |     |
| 2345-167 | 47377.33    | 16.59 | 0.18 | 15.71 | 0.12 | 14.66 | 0.17 |