

# Comet astrometry made at the Skalnaté Pleso Observatory in the year 1989

J. Svoreň

*Astronomical Institute of the Slovak Academy of Sciences  
059 60 Tatranská Lomnica, The Slovak Republic*

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**Abstract.** The paper presents the results of position photographing of comets carried out at the Skalnaté Pleso Observatory in the year 1989. A total of 71 observations of 8 comets are given.

**Key words:** comets – astrometry

## 1. Introduction

The presented paper is a continuation of the previous papers which gave the results of positional observations of comets made at the Skalnaté Pleso Observatory (the last paper of this series: Svoreň; 1995) and contains positional comet observations made in the year 1989.

The observations were made with a 0.3-m f/5 Zeiss astrograph. The reduction constants of the Skalnaté Pleso astrograph are as follows:

$$\lambda = -1^h 20^m 58.70^s,$$

$$\varphi = +49^\circ 11' 20.0'',$$

$$h = 1783 \text{ m m.s.l.},$$

$$\rho = 0.99836 \text{ of the equatorial radius of the Earth.}$$

The comets were photographed on ORWO plates with ZU 21 emulsion, dimensions 9x12 cm, which roughly corresponds to field of  $3^\circ \times 4^\circ$ . The reference stars required to compute positions using Schlesinger's method of dependences, from two independent triangles were selected from the Star Catalog of the Smithsonian Astrophysical Observatory (1966). The differences between independent determination of the equatorial coordinates, given for each position, provide some information about the accuracy of the measuring (but not about the accuracy of the object position). The rectangular coordinates of the reference stars and the comets were measured with the aid of instrument for measuring coordinates produced by Zeiss (Ascoremat E-60).

A total of 71 accurate positions of 8 comets, arranged according to the new system designation of the comets, are given. The list of collaborators is given, together with their share in photographing, measuring and reducing the positions.

## 2. Conversion from eqn. B1950.0 to eqn. J2000.0

The reference stars were selected from the Smithsonian Astrophysical Observatory Star Catalog(1966). The positions were measured in B1950.0 system and then converted to J2000.0 following the formulas published by System Transition Committee of the IAU Commission 20 (Yeomans, 1990). Conversion from eqn. B1950.0 to eqn. J2000.0 is as follows:

Let  $\alpha_0$  and  $\delta_0$  are object's right ascension and declination referred to 1950.0 system. Then the calculated rectangular components of the object's position vector  $\mathbf{r}_0$  referred to 1950.0 system are:

$$r_{0x} = \cos\alpha_0 \cos\delta_0 \quad (1)$$

$$r_{0y} = \sin\alpha_0 \cos\delta_0 \quad (2)$$

$$r_{0z} = \sin\delta_0 \quad (3)$$

The astrographic position vector  $\mathbf{r}_1$  is formed to remove the effects of elliptical aberration:

$$r_{1x} = r_{0x} - A_x + B r_{0x} \quad (4)$$

$$r_{1y} = r_{0y} - A_y + B r_{0y} \quad (5)$$

$$r_{1z} = r_{0z} - A_z + B r_{0z} \quad (6)$$

where B is a scalar product of the vector transpose to  $\mathbf{r}_0$  and the vector  $\mathbf{A}$ , i.e.

$$B = r_{0x} A_x + r_{0y} A_y + r_{0z} A_z \quad (7)$$

and  $A_x, A_y, A_z$  are the rectangular components of the vector  $\mathbf{A}$ :

$$A_x = -1.62557 \times 10^{-6}$$

$$A_y = -0.31919 \times 10^{-6}$$

$$A_z = -0.13843 \times 10^{-6}$$

If the  $t$  is Julian time of the observation, then the Julian centuries from 1950 epoch to the observation time can be calculated as

$$T = (t - 2433282.423) / 36525 \quad (8)$$

The rectangular components of the object's position vector  $\mathbf{r}$  referred to 2000.0 system are:

$$r_x = X_x r_{1x} + X_y r_{1y} + X_z r_{1z} \quad (9)$$

$$r_y = Y_x r_{1x} + Y_y r_{1y} + Y_z r_{1z} \quad (10)$$

$$r_z = Z_x r_{1x} + Z_y r_{1y} + Z_z r_{1z} \quad (11)$$

where  $X_x, X_y, \dots, Z_z$  are the elements of the rotation matrix (Murray, 1989):

$$\begin{aligned}
 X_x &= +0.9999256794956877 - 0.0026455262 \times 10^{-6} T \\
 X_y &= -0.0111814832204662 - 1.1539918689 \times 10^{-6} T \\
 X_z &= -0.0048590038153592 + 2.1111346190 \times 10^{-6} T \\
 Y_x &= +0.0111814832391717 + 1.1540628161 \times 10^{-6} T \\
 Y_y &= +0.9999374848933135 - 0.0129042997 \times 10^{-6} T \\
 Y_z &= -0.0000271625947142 + 0.0236021478 \times 10^{-6} T \\
 Z_x &= +0.0048590037723143 - 2.1112979048 \times 10^{-6} T \\
 Z_y &= -0.0000271702937440 - 0.0056024448 \times 10^{-6} T \\
 Z_z &= +0.9999881946023742 + 0.0102587734 \times 10^{-6} T
 \end{aligned}$$

The coordinates  $\alpha, \delta$  in J2000.0 system are calculated using the expressions:

$$\alpha = \arctg \frac{r_y}{r_x} + 90. \left(1 - \frac{r_x}{|r_x|}\right) \quad (12)$$

$$\delta = \arctg \frac{r_z}{\sqrt{r_x^2 + r_y^2}} \quad (13)$$

### 3. Positions of comets

The data have been arranged according to individual comets. The individual columns of the table contain the following:

N - ordinal number of observation,

Date U.T. - date and time of the middle of the exposure,

$R.A._{2000}$  - right ascension for equinox 2000.0 (in h,m,s),

$Decl._{2000}$  - declination for equinox 2000.0 (in  $^{\circ}, ', ''$ ),

T - the exposure time in minutes,

A - the difference between independent determinations of R.A. in arc seconds,

B - the difference between independent determinations of Decl. in arc seconds.

Note: N. 4 - position uncertain, N. 32 - poor guiding.

| N                         | Date U.T. | $R.A._{2000}$ | $Decl._{2000}$ | T           | A  | B       |
|---------------------------|-----------|---------------|----------------|-------------|----|---------|
| Comet 23P/Brorsen-Metcalf |           |               |                |             |    |         |
| 1                         | 1989 July | 11.02361      | 0 50 48.11     | +16 04 10.4 | 18 | 0.6 0.2 |
| 2                         | 1989 July | 25.96435      | 2 16 22.51     | +29 52 03.0 | 7  | 0.5 0.5 |
| 3                         | 1989 July | 25.98171      | 2 16 31.26     | +29 53 10.8 | 7  | 0.8 0.9 |
| 4                         | 1989 Aug. | 2.93056       | 3 34 08.86     | +37 40 54.1 | 4  | 1.0 1.4 |
| 5                         | 1989 Aug. | 2.96181       | 3 34 30.58     | +37 42 26.6 | 4  | 0.7 1.4 |

| N                                 | Date U.T. | $R.A.$ <sub>2000</sub> | $Decl.$ <sub>2000</sub> | T           | A  | B       |
|-----------------------------------|-----------|------------------------|-------------------------|-------------|----|---------|
| Comet 23P/Brorsen-Metcalf - cont. |           |                        |                         |             |    |         |
| 6                                 | 1989 Aug. | 6.98299                | 4 24 15.71              | +40 30 56.3 | 5  | 0.7 0.1 |
| 7                                 | 1989 Aug. | 7.00764                | 4 24 34.52              | +40 31 43.0 | 4  | 0.4 0.7 |
| 8                                 | 1989 Aug. | 7.04861                | 4 25 06.94              | +40 33 04.1 | 4  | 0.9 0.4 |
| 9                                 | 1989 Aug. | 7.06250                | 4 25 17.46              | +40 33 27.3 | 4  | 0.2 0.4 |
| 10                                | 1989 Aug. | 10.94306               | 5 17 20.56              | +41 52 43.2 | 4  | 0.1 0.1 |
| 11                                | 1989 Aug. | 10.95208               | 5 17 27.91              | +41 52 48.8 | 8  | 0.2 0.3 |
| 12                                | 1989 Aug. | 10.97072               | 5 17 42.99              | +41 52 58.8 | 3  | 0.1 0.1 |
| 13                                | 1989 Aug. | 10.97708               | 5 17 48.21              | +41 53 01.7 | 6  | 0.5 0.1 |
| 14                                | 1989 Aug. | 25.04491               | 8 01 21.01              | +35 40 32.0 | 3  | 0.4 0.1 |
| 15                                | 1989 Aug. | 25.05127               | 8 01 24.59              | +35 40 12.0 | 3  | 0.7 0.6 |
| 16                                | 1989 Sep. | 2.10937                | 9 02 23.59              | +28 26 08.1 | 3  | 0.5 0.8 |
| Comet 65P/Gunn                    |           |                        |                         |             |    |         |
| 17                                | 1989 Mar. | 7.00278                | 15 20 34.45             | -10 07 10.7 | 26 | 0.1 0.7 |
| 18                                | 1989 Mar. | 7.12917                | 15 20 37.08             | -10 07 19.4 | 26 | 0.1 0.4 |
| Comet 78P/Gehrels 2               |           |                        |                         |             |    |         |
| 19                                | 1989 Nov. | 3.03264                | 2 27 11.78              | +13 49 13.8 | 50 | 0.1 0.1 |
| 20                                | 1989 Nov. | 3.09861                | 2 27 09.35              | +13 48 47.5 | 50 | 0.3 0.3 |
| Comet 93P/Lovas 1                 |           |                        |                         |             |    |         |
| 21                                | 1989 Nov. | 18.75486               | 7 12 48.63              | +45 36 57.3 | 50 | 1.2 0.7 |
| 22                                | 1989 Nov. | 18.81944               | 7 12 51.30              | +45 37 14.6 | 50 | 0.6 1.3 |
| 23                                | 1989 Nov. | 19.80208               | 7 13 30.23              | +45 41 41.9 | 50 | 0.4 0.7 |
| 24                                | 1989 Nov. | 19.87708               | 7 13 33.02              | +45 42 01.9 | 50 | 1.0 0.3 |
| 25                                | 1989 Nov. | 20.83750               | 7 14 07.55              | +45 46 05.5 | 50 | 0.7 0.2 |
| 26                                | 1989 Nov. | 20.89861               | 7 14 09.18              | +45 46 22.0 | 50 | 0.4 0.3 |
| 27                                | 1989 Nov. | 23.94595               | 7 15 35.58              | +45 58 35.0 | 30 | 0.4 1.2 |
| 28                                | 1989 Nov. | 24.01100               | 7 15 36.83              | +45 58 49.6 | 30 | 0.4 0.6 |
| 29                                | 1989 Nov. | 29.79931               | 7 16 45.86              | +46 17 18.8 | 25 | 0.5 1.1 |
| 30                                | 1989 Nov. | 29.87865               | 7 16 46.12              | +46 17 34.6 | 25 | 0.1 1.0 |
| 31                                | 1989 Dec. | 27.79641               | 6 59 46.47              | +45 37 11.2 | 20 | 0.9 0.6 |
| 32                                | 1989 Dec. | 27.90081               | 6 59 40.36              | +45 36 31.8 | 20 | 1.3 0.4 |
| 33                                | 1989 Dec. | 29.77593               | 6 57 51.35              | +45 24 08.8 | 25 | 1.1 1.0 |
| 34                                | 1989 Dec. | 30.70081               | 6 56 58.05              | +45 17 35.2 | 25 | 0.9 0.4 |
| 35                                | 1989 Dec. | 30.76250               | 6 56 54.45              | +45 17 10.4 | 25 | 0.7 0.6 |
| Comet C/1989 A1 (Yanaka)          |           |                        |                         |             |    |         |
| 36                                | 1989 Mar. | 7.02917                | 15 18 08.36             | +35 44 59.5 | 30 | 0.4 0.3 |
| 37                                | 1989 Mar. | 7.07986                | 15 18 09.77             | +35 46 13.3 | 30 | 0.2 0.8 |
| 38                                | 1989 Mar. | 8.88056                | 15 19 03.40             | +36 31 09.4 | 30 | 1.0 0.5 |
| 39                                | 1989 Mar. | 8.93547                | 15 19 04.85             | +36 32 34.4 | 30 | 0.8 0.3 |

| N                                      | Date U.T. | <i>R.A.</i> <sub>.2000</sub> | <i>Decl.</i> <sub>.2000</sub> | T           | A  | B   |     |
|--|-----------|------------------------------|-------------------------------|-------------|----|-----|-----|
| Comet C/1989 Q1 (Okazaki-Levy-Rudenko) |           |                              |                               |             |    |     |     |
| 40                                     | 1989 Sep. | 12.77274                     | 15 01 49.60                   | +32 16 07.2 | 5  | 0.6 | 0.1 |
| 41                                     | 1989 Sep. | 12.79340                     | 15 01 48.00                   | +32 15 58.8 | 5  | 0.3 | 0.1 |
| 42                                     | 1989 Sep. | 19.75903                     | 14 53 55.35                   | +31 36 06.5 | 6  | 0.8 | 0.5 |
| 43                                     | 1989 Sep. | 19.77465                     | 14 53 54.18                   | +31 35 58.1 | 30 | 0.6 | 0.9 |
| 44                                     | 1989 Sep. | 19.78889                     | 14 53 53.47                   | +31 35 54.1 | 4  | 0.3 | 0.2 |
| 45                                     | 1989 Sep. | 21.79236                     | 14 51 46.01                   | +31 24 45.6 | 4  | 0.1 | 0.3 |
| 46                                     | 1989 Nov. | 3.13576                      | 13 55 15.18                   | +23 23 41.2 | 3  | 1.0 | 0.3 |
| Comet C/1989 T1 (Helin-Roman-Alu)      |           |                              |                               |             |    |     |     |
| 47                                     | 1989 Oct. | 20.77454                     | 22 40 30.16                   | +10 21 34.3 | 25 | 0.4 | 0.9 |
| 48                                     | 1989 Oct. | 22.74780                     | 22 29 45.54                   | +12 19 13.5 | 25 | 0.5 | 0.2 |
| 49                                     | 1989 Oct. | 22.84063                     | 22 29 14.94                   | +12 24 43.4 | 20 | 0.3 | 0.9 |
| 50                                     | 1989 Oct. | 23.77593                     | 22 24 11.77                   | +13 19 59.7 | 25 | 0.4 | 0.2 |
| 51                                     | 1989 Nov. | 18.71806                     | 20 31 05.16                   | +33 09 54.1 | 24 | 0.4 | 0.2 |
| 52                                     | 1989 Nov. | 18.78958                     | 20 30 51.00                   | +33 12 11.8 | 20 | 0.7 | 0.1 |
| 53                                     | 1989 Nov. | 19.71806                     | 20 27 52.53                   | +33 42 23.2 | 26 | 0.5 | 0.1 |
| 54                                     | 1989 Nov. | 19.83403                     | 20 27 30.10                   | +33 46 02.8 | 26 | 0.4 | 0.7 |
| 55                                     | 1989 Nov. | 29.70035                     | 19 59 00.98                   | +38 31 41.9 | 15 | 0.4 | 0.5 |
| 56                                     | 1989 Nov. | 29.81736                     | 19 58 42.59                   | +38 34 41.0 | 15 | 0.9 | 0.2 |
| 57                                     | 1989 Dec. | 27.67731                     | 18 52 17.23                   | +48 48 25.5 | 10 | 0.7 | 0.5 |
| 58                                     | 1989 Dec. | 28.68038                     | 18 49 54.68                   | +49 08 19.0 | 12 | 1.0 | 0.2 |
| 59                                     | 1989 Dec. | 28.71887                     | 18 49 49.38                   | +49 08 58.8 | 12 | 1.1 | 0.8 |
| 60                                     | 1989 Dec. | 30.68287                     | 18 45 08.65                   | +49 47 38.5 | 15 | 0.6 | 0.5 |
| 61                                     | 1989 Dec. | 30.72581                     | 18 45 01.93                   | +49 48 24.3 | 15 | 0.1 | 0.5 |
| 62                                     | 1989 Dec. | 31.67940                     | 18 42 44.49                   | +50 07 15.8 | 12 | 0.4 | 0.2 |
| Comet C/1989 Y2 (McKenzie-Russell)     |           |                              |                               |             |    |     |     |
| 63                                     | 1989 Dec. | 27.81424                     | 4 25 25.56                    | +1 17 53.1  | 20 | 0.7 | 1.0 |
| 64                                     | 1989 Dec. | 27.87685                     | 4 25 03.63                    | +1 17 06.1  | 20 | 0.6 | 0.7 |
| 65                                     | 1989 Dec. | 28.78872                     | 4 20 01.74                    | +1 05 28.3  | 22 | 0.9 | 1.1 |
| 66                                     | 1989 Dec. | 28.81094                     | 4 19 53.59                    | +1 05 09.8  | 22 | 0.4 | 1.1 |
| 67                                     | 1989 Dec. | 29.74815                     | 4 14 53.75                    | +0 53 43.9  | 22 | 0.4 | 0.2 |
| 68                                     | 1989 Dec. | 29.79531                     | 4 14 38.50                    | +0 53 10.2  | 22 | 0.2 | 0.5 |
| 69                                     | 1989 Dec. | 30.74330                     | 4 09 44.23                    | +0 42 20.2  | 20 | 0.9 | 0.1 |
| 70                                     | 1989 Dec. | 30.78831                     | 4 09 30.59                    | +0 41 46.0  | 20 | 0.9 | 0.2 |
| 71                                     | 1989 Dec. | 31.72361                     | 4 04 50.91                    | +0 31 32.7  | 22 | 0.4 | 0.6 |

#### 4. List of collaborators

| Name          | Exposures | Measurements | Reductions |
|---------------|-----------|--------------|------------|
| J. Borošová   | 4         | 2            | –          |
| G. Červák     | 29        | 31           | –          |
| P. Rychtarčík | 38        | 38           | –          |
| J. Svoreň     | –         | –            | 71         |

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