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**JPAR**

**Review**

# Some aspects of the oldest nearby moving cluster (Ruprecht 147)

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**Based on the membership data retrieved from the Two Micron All Sky Survey (2MASS), we have computed some parameters of the moving open cluster Ruprecht 147, like, vertex, velocity, distance, distance modulus, and center of the cluster. All of these aspects were carried out using an algorithm due to Sharaf et al. (2000), into which error estimates of these parameters will be established in closed analytical forms (e.g. standard and probable errors of the vertex coordinates, angular distance, velocity of the cluster, parallaxes of member stars, and distance of the cluster).**
**Finally, we compared our results with other published values, which is in good agreement.**

**Key words**: Ruprecht 147, characteristics, convergent point, error controlled method, cluster

## INTRODUCTION

In modern astronomy, stellar structure and evolution are among the most important topics. Stellar groups (clusters and associations) occupy a predominant place in these subjects. A moving cluster is a group of stars whose parallel motions in space yield, on the celestial sphere, directions of proper motion that appear to converge to a point called the vertex.
Open clusters are important laboratories for testing stellar evolution models and for describing the star formation history of the galaxy, since each cluster contains samples of stars of a single age and (probably) composition. As is well known, determining distances is the most fundamental step to measuring cluster ages and other key properties, Marc et al. (2004).
In the present paper, we focus on Ruprecht 147 (hereafter Rp147). Rp147 was originally discovered in 1830 by John Herschel, who described it as “a very large straggling space full of loose stars” (Herschel 1833), and labeled it GC 4481 (Herschel1863).
The name we use here originates from Ruprecht (1966), who classified Rp147 as III-2-m cluster in the Trumpler system (Trumpler 1930). Archinal and Hynes (2003) describes Rp147 as a ”$45^{/}$ sized V-shaped group of bright stars” that is “a sparse possible open cluster”, and estimate the cluster center as the location of HD 180228 (while this star’s photometry apparently places it on the Rp147 red giant branch, the proper motions from Tycho-2 (-1.6, -6.3 mas/yr) and UCAC-3 (-3.5, -4.0 mas/yr) are inconsistent with cluster membership).
Fortunately, Dias et al. (2001) and Kharchenko et al. (2005) used catalog data to identify Ruprecht 147 (Rp147=NGC 6774), and estimated its age to be to be 2.5 Gyr at a distance 175 – 270 pc, making Rp147 by far the oldest nearby cluster. Recently, Curtis et al. (2013), determined some of its properties, like, age 2.51±0.25 Gyr, distance 295±15 pc and $V = 40.7$ km/s.

## BASIC FORMULATIONS

For $N_i$ group of membership of cluster stars, whose coordinates $(\alpha,\delta)$ moving with $(V_\alpha,V_\delta)$, proper motion $\mu$ $(mas/yr)$, distance $r$ $(pc)$ and radial velocity $V_r\,(km/s)$, we can compute the characteristics of Rp147 with an error controlled method designed by Sharaf et al. (2000).

- ***The vertex of the cluster (A,D)***

It's assumed that all cluster members have the same space velocities, we have

$$X = V\cos D\cos A, \tag{1}$$

$$Y = V\cos D\sin A, \tag{2}$$

$$Z = V\sin D, \tag{3}$$

where, $X$, $Y$ and $Z$ are *V's* components along $x$, $y$ and $z$ axes of a coordinate system whose center is the Sun. We can express $(X,Y,Z)$ by well-known formulae (Smart 1958), we have

$$X = -4.74r\mu_\alpha\cos\delta\sin\alpha - 4.74r\mu_\delta\sin\delta\cos\alpha + V_r\cos\delta\cos\alpha, \tag{4}$$

$$Y = +4.74r\mu_\alpha\cos\delta\cos\alpha - 4.74r\mu_\delta\sin\delta\sin\alpha + V_r\cos\delta\sin\alpha, \tag{5}$$

$$Z = +4.74r\mu_\delta\cos\delta + V_r\sin\delta, \tag{6}$$

From the above equations and letting

$$\xi = X/Z, \tag{7}$$

$$\eta = Y/Z, \tag{8}$$

we get

$$a_i\xi + b_i\eta = c_i, \tag{9}$$

where the coefficients

$$\begin{aligned} a_i &= \mu_\alpha^{(i)}\sin\delta_i\cos\alpha_i\cos\delta_i - \mu_\delta^{(i)}\sin\alpha_i, \\ b_i &= \mu_\alpha^{(i)}\sin\delta_i\sin\alpha_i\cos\delta_i + \mu_\delta^{(i)}\cos\alpha_i, \\ c_i &= \mu_\alpha^{(i)}\cos^2\delta_i. \end{aligned} \tag{10}$$

and the index $i$ varies from $1$ to $N$ which is the number of the cluster members. So

$$\tan A = \eta/\xi, \tag{11}$$

$$\tan D = \left(\xi^2 + \eta^2\right)^{-1/2}. \tag{12}$$

The required coordinates $(A,D)$ of the cluster vertex follow directly from Equations (11) and (12). Corrections of the vertex coordinates were determined using Sharaf et al. (2000) algorithm, applying a repeated iterative process until the desired accuracy is achieved as it is shown in the mentioned algorithm. Getting the more accurate values of, the corrected values of the coordinates of the vertex, $A^*$ and $D^*$ were obtained using the following equations:

$$A^* = A + \Delta A, \tag{13}$$

$$D^* = D + \Delta D. \tag{14}$$

- ***The velocity of the cluster***

The velocity of the cluster could be considered as

$$V = \sum_{i=1}^{N} V_r^{(i)}\cos\lambda_i \Big/ \sum_{i=1}^{N}\cos^2\lambda_i. \tag{15}$$

where $\lambda$ is the angular distance of the star from the vertex, i.e.

$$\cos\lambda_i = \sin\delta_i\sin D + \cos\delta_i\cos D\cos(A - \alpha_i). \tag{16}$$

- ***The distance of the cluster***

The distance *d (in parsec)* of the cluster is given by

$$d = N\Big/\sum_{i=1}^{N} p_i \tag{17}$$

where $p_i$ are parallaxes of a member stars, which given as

$$p_i = 4.74\mu_i/V\sin\lambda_i. \tag{18}$$

- ***The distance modulus of the cluster***

i.e.

$$m - M = -5 + 5\log d. \tag{19}$$

- ***The center of the cluster***

The equatorial coordinates $(\alpha, \delta)$ and the distance $d$ (pc) of each star enables us to calculate the heliocentric coordinates $(x, y, z)$, the center of the cluster can then be derived by the simple method of finding the equatorial coordinates of the center of mass for a number of discrete objects, say $(x_c, y_c, z_c)$:

$$x_c = \left[\sum_{i=1}^{N} \cos\delta_i \cos\alpha_i / p_i\right] \Big/ N, \tag{20}$$

$$y_c = \left[\sum_{i=1}^{N} \cos\delta_i \sin\alpha_i / p_i\right] \Big/ N, \tag{21}$$

$$z_c = \left[\sum_{i=1}^{N} \sin\delta_i / p_i\right] \Big/ N. \tag{22}$$

- ***Standard and probable errors of the vertex coordinates***

*1.* $\sigma_A$, $r_A$

$$\sigma_A = \frac{\sigma_1}{\xi^2 + \eta^2}\left\{-\frac{1}{\Delta}\left[T_4\eta^2 + T_1\xi^2 + 2\eta\xi T_2\right]\right\}^{1/2}, \tag{23}$$

$$r_A = 0.6745\sigma_A, \tag{24}$$

*2.* $\sigma_D$, $r_D$

$$\sigma_D = \frac{\sigma_1}{\left(\xi^2 + \eta^2 + 1\right)}\left\{-\frac{1}{\Delta\left(\xi^2 + \eta^2\right)}\left[T_4\xi^2 + T_1\eta^2 - 2\xi\eta T_2\right]\right\}^{1/2}, \tag{25}$$

$$r_D = 0.6745\sigma_D, \tag{26}$$

where

$$\sigma_1 = \left[\frac{1}{N-2}\left\{T_6 - \xi^2 T_1 - \eta^2 T_4 - 2\xi\eta T_2\right\}\right]^{1/2}, \tag{27}$$

and $T_j\ (j = 1, 2, ..., 6)$ are given by

$$\begin{array}{lll} T_1 = \sum_{i=1}^{N} a_i^2 \quad ; & T_2 = \sum_{i=1}^{N} a_i b_i \quad ; & T_3 = \sum_{i=1}^{N} a_i c_i \quad ; \\ T_4 = \sum_{i=1}^{N} b_i^2 \quad ; & T_5 = \sum_{i=1}^{N} b_i c_i \quad ; & T_6 = \sum_{i=1}^{N} c_i^2 \quad . \end{array} \tag{28}$$

- ***Standard and probable errors of $\lambda_i$, $V$, $p_i$, and $d$; $i = 1, 2, ..., N$***

The standard errors of these parameters are given by the following equations

$$\sigma_{\lambda_i} = \sigma_2\left\{-\frac{1}{E}\left[H_i^2 G_1 + R_i^2 G_4 - 2H_i R_i G_2\right]\right\}^{1/2}, \tag{29}$$

$$\sigma_V = \sigma_2\left\{-\frac{1}{E}\left[\Lambda^2 G_1 + W^2 G_4 - 2\Lambda W G_2\right]\right\}^{1/2}, \tag{30}$$

$$\sigma_{P_i} = \sigma_2 \left\{ -\frac{1}{E} \left[ \Gamma_i^2 G_1 + \Theta_i^2 G_4 - 2\Gamma_i \Theta_i G_2 \right] \right\}^{1/2}, \tag{31}$$

$$\sigma_d = \sigma_2 \left\{ -\frac{1}{E} \left[ \chi^2 G_1 + \beta^2 G_4 - 2\chi\beta G_2 \right] \right\}^{1/2}, \tag{32}$$

where

$$\sigma_2 = \left[ \frac{1}{N-2} \left\{ G_6 - (\Delta A)^2 G_1 - (\Delta D)^2 G_4 - 2(\Delta A)(\Delta D) G_2 \right\} \right]^{1/2}, \tag{33}$$

and $G_j \left( j = 1,2,...,6 \right)$ are given by

$$\begin{aligned} G_1 &= \sum_{i=1}^{N} \Psi_i^2 \quad ; \quad G_2 = \sum_{i=1}^{N} \Phi_i \Psi_i \quad ; \quad G_3 = \sum_{i=1}^{N} \Psi_i \Delta\theta_i \quad ; \\ G_4 &= \sum_{i=1}^{N} \Phi_i^2 \quad ; \quad G_5 = \sum_{i=1}^{N} \Phi_i \Delta\theta_i \quad ; \quad G_6 = \sum_{i=1}^{N} \left( \Delta\theta_i \right) \quad . \end{aligned} \tag{34}$$

where

$$\Delta\theta_i = \Psi_i \Delta A + \Phi_i \Delta D, \tag{35}$$

$$\Psi = \sin^2\theta \left\{ \cos\delta \tan D \cos(A-\alpha) - \sin\delta \right\} / \sin^2(A-\alpha), \tag{36}$$

$$\Phi = -\sin^2\theta \left[ \cos\delta \sec^2 D \sin(A-\alpha) \right] / \sin^2(A-\alpha), \tag{37}$$

$$\Delta A = \left( G_5 G_2 - G_3 G_4 \right) / E, \tag{38}$$

$$\Delta D = \left( G_3 G_2 - G_5 G_1 \right) / E, \tag{39}$$

$$E = G_2^2 - G_4 G_1. \tag{40}$$

while $\theta$ was defined from the spherical triangle north celestial pole-star-vertex, thus we have, $\cot\theta = \cos\delta \tan D \csc(A-\alpha) - \sin\delta \cot(A-\alpha)$.

also

$$H_i = \left[ \cos\delta_i \sin D \cos(A-\alpha_i) - \sin\delta_i \cos D \right] / \sin\lambda_i, \tag{41}$$

$$R_i = \left[ \cos\delta_i \cos D \sin(A-\alpha_i) \right] / \sin\lambda_i, \tag{42}$$

$$\Lambda = \frac{\sum_{i=1}^{N} \left( 2V\cos\lambda_i - V_r^{(i)} \right) \left( \cos\delta_i \sin D \cos(A-\alpha_i) - \sin\delta_i \cos D \right)}{\sum_{i=1}^{N} \cos^2\lambda_i}, \tag{43}$$

$$W = \frac{\sum_{i=1}^{N} \left( 2V\cos\lambda_i - V_r^{(i)} \right) \left( \cos\delta_i \cos D \sin(A-\alpha_i) \right)}{\sum_{i=1}^{N} \cos^2\lambda_i}, \tag{44}$$

$$\Gamma_i = -p_i \left( H_i \cot\lambda_i + \frac{\Lambda}{V} \right), \tag{45}$$

$$\Theta_i = -p_i \left( R_i \cot\lambda_i + \frac{W}{V} \right), \tag{46}$$

$$\chi = -\frac{d^2}{N} \sum_{i=1}^{N} \Gamma_i, \tag{47}$$

$$\beta = -\frac{d^2}{N} \sum_{i=1}^{N} \Theta_i. \tag{48}$$

Then the corresponding probable errors are

$$e_{\lambda_i} = 0.6745\sigma_{\lambda_i}, \tag{49}$$

$$e_V = 0.6745\sigma_V, \tag{50}$$

$$e_{p_i} = 0.6745\sigma_{p_i}, \tag{51}$$

$$e_d = 0.6745\sigma_d. \tag{52}$$

- ***The solar motion***

The solar apex with respect to a given group of stars is the point towards which the Sun is moving. Now if $\overline{U}$, $\overline{V}$ and $\overline{W}$ are the components of the mean velocity with respect to the Sun, of the given group of stars, the $-\overline{U}$, $-\overline{V}$ and $-\overline{W}$, are the components of the solar velocity with respect to this same group and referred to the same axes as $\overline{U}$, $\overline{V}$ and $\overline{W}$.
The components $U$, $V$ and $W$ (i.e. the system of galactic space coordinates) can be computed by the transformation formulae by Murray (1989), this formulae were applied by Elsanhoury et al. (2013) to compute the velocity ellipsoid parameters of open clusters (e.g. Hyades). The direction to the galactic pole in the new *J2000.0* equatorial system is $\alpha_G = 12^h 51^m 26^s.2755;\ \delta_G = 27^\circ 7' 41''.704$.

i.e.

$$\left.\begin{aligned} U &= -0.054875539X & -0.873437105Y & -0.483834992Z, \\ V &= \phantom{-}0.494109454X & -0.444829594Y & +0.746982249Z, \\ W &= -0.867666136X & -0.198076390Y & +0.455983795Z. \end{aligned}\right\} \tag{53}$$

In order to compute the galactic coordinates of the apex, that is the point towards which $-\overline{U}$, $-\overline{V}$, $-\overline{W}$ is directed, remember that the $U$ components are referred to an axis pointing towards $l = 180^0$, $b = 0^0$, whereas the first axis of the galactic space coordinate system is directed towards the galactic center $\left(l = 0^0,\ b = 0^0\right)$. Therefore, denoting the galactic longitude and galactic latitude of the Solar apex respectively by $l_A$ and $b_A$, we will have:

$$l_A = \tan^{-1}\left(-\overline{V}/\overline{U}\right) \tag{54}$$

$$b_A = \sin^{-1}\left(-\overline{W}/S\right) \tag{55}$$

$$S = \left(\overline{U}^2 + \overline{V}^2 + \overline{W}^2\right)^{\frac{1}{2}}. \quad km/\text{sec}. \tag{56}$$

where $S$ is the absolute value of the Sun's velocity relative to the stars considered. Usually $S$ is called the *Sun's velocity*, although it is not a vector, these three quantities (i.e. $l_A$, $b_A$ and $S$), are sometimes called the elements of the Solar motion with respect to a group of stars.

## NUMERICAL APPLICATIONS

The above equations have been applied to the open cluster Rp147, to determine its characteristics. Table 1 lists 74 members used in this paper, which are collected by Curtis et al. (2013), into which cluster members are identified by their common space motion, determined from proper motions, radial velocities, and by their placement on the color-magnitude diagram (CMD). They utilized NOMAD (Zacharias et al. 2004a), UCAC-3 (Zacharias et al. 2010), and PPMXL (Roeser et al. 2010) astrometric catalogs for proper motions. NOMAD combines data (positions, proper motions, and BVR/JHK photometry) for over 1 billion stars from the Hipparcos (Perryman and ESA 1997), Tycho-2 (Høg et al. 2000), UCAC-2 (Zacharias et al. 2004b), USNO-B1.0 (Monet et al. 2003), and 2MASS (Skrutskie et al.2006)catalogs.
They performed initial radial velocity confirmation of suspected members to verify the existence of the cluster with the Hamilton echelle spectrometer on the 120 inch Shane telescope at Lick Observatory (R~50,000; Vogt1987). The objectives were to obtain RV's of known and suspected members, to identify new members, and to obtain high resolutions spectra of the brightest members at high signal-to-noise ratios (SNRs) for more detailed analysis of abundances and chromospheric activity.

**Table 1.**Rp147 membership data list

| CWW ID | 2MASS ID | $\mu_\alpha$ (mas) | $\mu_\delta$ (mas) | $RV_{LP}$ (km/s) | $\lambda_i \pm \delta_{\lambda_i}$ (deg.) | $p_i \pm \delta_{p_i}$ (mas) |
|---|---|---|---|---|---|---|
| 1 | 19152612-1605571 | -1 | -27.4 | 38.5 | 2.671±0.035 | 5.921±0.722 |
| 2 | 19172384-1604243 | -2.2 | -27.6 | 43.4 | 2.668±0.035 | 5.942±0.722 |
| 3 | 19171130-1603082 | -0.9 | -29.1 | 42.7 | 2.668±0.035 | 6.249±0.759 |
| 4 | 19170343-1703138 | -0.7 | -30.1 | 46.2 | 2.684±0.035 | 6.681±0.831 |
| 5 | 19183747-1712575 | -0.4 | -26.7 | 42.4 | 2.685±0.035 | 5.930±0.739 |
| 6 | 19140272-1554055 | -0.4 | -26.1 | 42.1 | 2.669±0.035 | 5.622±0.683 |
| 7 | 19155129-1617591 | -2.7 | -26.8 | 41.4 | 2.674±0.035 | 5.847±0.716 |
| 8 | 19180978-1616222 | -1.4 | -27.3 | 44.2 | 2.670±0.035 | 5.893±0.718 |
| 9 | 19131526-1706210 | -0.1 | -27.1 | 46.4 | 2.690±0.035 | 6.088±0.763 |
| 10 | 19134817-1650059 | -1.5 | -26.2 | 43.6 | 2.685±0.035 | 5.832±0.725 |
| 11 | 19164574-1635226 | -1.6 | -27.1 | 46.1 | 2.677±0.035 | 5.936±0.731 |
| 12 | 19165670-1612265 | -1.7 | -26.8 | 44.2 | 2.671±0.035 | 5.796±0.707 |
| 13 | 19193373-1658514 | 0.3 | -26.2 | 47.2 | 2.680±0.035 | 5.758±0.712 |
| 14 | 19160865-1611148 | -3.4 | -29.3 | 41.8 | 2.671±0.035 | 6.374±0.778 |
| 15 | 19132220-1645096 | -5.4 | -29.1 | 41.9 | 2.684±0.035 | 6.559±0.815 |
| 16 | 19154269-1633050 | -1.8 | -30.3 | 34.7 | 2.678±0.035 | 6.648±0.819 |
| 17 | 19172865-1633313 | 1.1 | -27.6 | 41.8 | 2.676±0.035 | 6.022±0.740 |
| 18 | 19133648-1548104 | -1.4 | -28.5 | 40.7 | 2.668±0.035 | 6.132±0.744 |
| 19 | 19153282-1620388 | 0.2 | -27.1 | 46.1 | 2.675±0.035 | 5.898±0.723 |
| 20 | 19152638-1700159 | -2.1 | -29.6 | 43.9 | 2.686±0.035 | 6.602±0.823 |
| 21 | 19173931-1636348 | 1.2 | -25.4 | 41.6 | 2.676±0.035 | 5.550±0.683 |
| 22 | 19155841-1615258 | -2.8 | -28.9 | 41.4 | 2.673±0.035 | 6.292±0.769 |
| 23 | 19195154-1603583 | -2.4 | -27.3 | 41.7 | 2.664±0.035 | 5.841±0.707 |
| 24 | 19151540-1619517 | -1.8 | -26.8 | 45.9 | 2.675±0.035 | 5.847±0.717 |
| 25 | 19181155-1629141 | 1.4 | -27 | 41.2 | 2.674±0.035 | 5.869±0.719 |
| 26 | 19165477-1702129 | 3.2 | -28.7 | 45.8 | 2.684±0.035 | 6.403±0.797 |
| 27 | 19163976-1626316 | 0.1 | -24.8 | 45.1 | 2.675±0.035 | 5.399±0.662 |
| 28 | 19153626-1557460 | -0.7 | -27.2 | 46.4 | 2.668±0.035 | 5.848±0.710 |
| 29 | 19163344-1607515 | -2.5 | -27.6 | 34.6 | 2.670±0.035 | 5.972±0.727 |
| 30 | 19142651-1606340 | -2.5 | -27.2 | 45.1 | 2.672±0.035 | 5.915±0.722 |
| 31 | 19150275-1609405 | -5.2 | -28.3 | 42.7 | 2.672±0.035 | 6.226±0.760 |
| 32 | 19163339-1620215 | -3 | -24.9 | 42.1 | 2.673±0.035 | 5.440±0.666 |
| 33 | 19170481-1636526 | 4.3 | -28.6 | 45.9 | 2.677±0.035 | 6.319±0.778 |
| 34 | 19183120-1614421 | -1.8 | -26.9 | 44.6 | 2.669±0.035 | 5.801±0.706 |
| 35 | 19180054-1636016 | 1.3 | -26.3 | 44.9 | 2.676±0.035 | 5.740±0.705 |
| 36 | 19164495-1717074 | 2.7 | -27.2 | 42.2 | 2.689±0.035 | 6.115±0.766 |
| 37 | 19150860-1657412 | -2 | -30 | 45.7 | 2.686±0.035 | 6.686±0.833 |
| 38 | 19163525-1705075 | 3.7 | -28 | 45.5 | 2.686±0.035 | 6.277±0.782 |
| 39 | 19131541-1616123 | -5.6 | -30 | 44.5 | 2.677±0.035 | 6.657±0.817 |
| 40 | 19164662-1619208 | 0 | -26.4 | 46.3 | 2.673±0.035 | 5.723±0.700 |
| 41 | 19142907-1549056 | 0.3 | -25.3 | 46.2 | 2.667±0.035 | 5.428±0.658 |
| 42 | 19163620-1607363 | -3 | -29.5 | 44.9 | 2.670±0.035 | 6.388±0.778 |
| 43 | 19162169-1609510 | -0.9 | -27.7 | 39.2 | 2.671±0.035 | 5.983±0.730 |
| 44 | 19165573-1603220 | -0.8 | -30.2 | 48.9 | 2.668±0.035 | 6.490±0.789 |
| 45 | 19160452-1605313 | -0.6 | -32.1 | 45.4 | 2.670±0.035 | 6.921±0.843 |
| 46 | 19200522-1535360 | 1.1 | -25.8 | 40.7 | 2.656±0.035 | 5.420±0.648 |
| 47 | 19170433-1623185 | -0.2 | -28.6 | 41.9 | 2.673±0.035 | 6.208±0.760 |
| 48 | 19172172-1535592 | -0.4 | -28.1 | 44.6 | 2.660±0.035 | 5.943±0.714 |
| 49 | 19114731-1632485 | 0.8 | -27.1 | 43.5 | 2.683±0.035 | 5.999±0.743 |
| 50 | 19145840-1650089 | -4.5 | -29.1 | 42.2 | 2.684±0.035 | 6.518±0.809 |
| 51 | 19164922-1613222 | -0.5 | -24.9 | 45 | 2.671±0.035 | 5.381±0.657 |

**Table 1.**Cont.

| | | | | | | |
|---|---|---|---|---|---|---|
| 52 | 19152981-1551047 | -1.8 | -26.5 | 39.7 | 2.667±0.035 | 5.689±0.689 |
| 53 | 19154511-1623157 | -0.1 | -27 | 41.4 | 2.675±0.035 | 5.882±0.722 |
| 54 | 19160523-1652561 | -3.5 | -26.8 | 42.5 | 2.683±0.035 | 5.975±0.742 |
| 55 | 19150925-1552241 | -0.1 | -28.6 | 42.1 | 2.668±0.035 | 6.136±0.744 |
| 56 | 19161121-1621485 | 4.2 | -25.5 | 39.5 | 2.674±0.035 | 5.613±0.688 |
| 57 | 19160879-1524279 | -3.8 | -30.5 | 40.8 | 2.659±0.035 | 6.477±0.776 |
| 58 | 19142816-1620023 | -2.6 | -28.6 | 42.3 | 2.676±0.035 | 6.264±0.769 |
| 59 | 19151897-1639244 | -2.1 | -25.5 | 41.2 | 2.680±0.035 | 5.629±0.696 |
| 60 | 19152406-1621519 | -1.3 | -29.6 | 47.9 | 2.675±0.035 | 6.455±0.792 |
| 61 | 19134126-1610201 | -5.3 | -29.5 | 42 | 2.674±0.035 | 6.510±0.797 |
| 62 | 19141294-1554291 | -1.8 | -26.6 | 46.7 | 2.669±0.035 | 5.739±0.698 |
| 63 | 19165940-1635271 | -2.8 | -27.7 | 42.6 | 2.677±0.035 | 6.082±0.749 |
| 64 | 19160589-1629481 | -0.3 | -28.7 | 44.7 | 2.677±0.035 | 6.269±0.771 |
| 65 | 19160785-1610360 | -4.5 | -26.8 | 45 | 2.671±0.035 | 5.867±0.716 |
| 66 | 19163672-1713101 | -0.1 | -31.8 | 42 | 2.688±0.035 | 7.105±0.888 |
| 67 | 19164725-1604093 | -2.2 | -29.5 | 42.8 | 2.669±0.035 | 6.359±0.773 |
| 68 | 19162203-1546159 | 1.5 | -27.6 | 41.8 | 2.664±0.035 | 5.892±0.712 |
| 69 | 19152141-1600107 | -2.6 | -27.1 | 43.5 | 2.669±0.035 | 5.861±0.713 |
| 70 | 19151156-1726308 | -0.5 | -27 | 40.8 | 2.693±0.035 | 6.104±0.769 |
| 71 | 19170285-1605166 | -1.7 | -27.9 | 40.9 | 2.669±0.035 | 6.008±0.731 |
| 72 | 19162656-1614545 | 0.4 | -29.5 | 43.2 | 2.672±0.035 | 6.386±0.780 |
| 73 | 19153354-1625368 | -9 | -31.6 | 46.3 | 2.676±0.035 | 7.149±0.878 |
| 74 | 19163732-1600050 | -2.9 | -34.8 | 42.5 | 2.668±0.035 | 7.493±0.910 |

Column Notes: (1) CWW ID –This work's star identification scheme, sorted by *V* magnitude. CWW = Curtis, Wolfgand and Wright. (2) 2MASS ID, also provides RA and Dec positions. (3,4) Ra. and Dec. proper motions in mas/yr. (5) Lick / Palomar RV in km/s. (6) $\lambda_i$ , our computed angular distance to the vertex in deg., and (7) $p_i$ , our computed parallaxes in mas.

## NUMERICAL RESULTS

Here, and with aid of *mathematica* software programming, we constructed an algorithm to compute the following parameters:

1. The vertex $(A,D)$ of the cluster and their standard errors $(\Delta A,\Delta D)$.
2. The velocity of the cluster and its errors $(\text{i.e. } V \pm \sigma_V)$.
3. The distance of the cluster and its errors $(\text{i.e. } d \pm \sigma_d)$.
4. The distance modulus $(\text{i.e. } m - M)$ of the star cluster.
5. Center of the cluster $(\text{i.e. } x_c, y_c, z_c)$ in parsecs.
6. $(\overline{X},\overline{Y},\overline{Z})$ and $(\overline{U},\overline{V},\overline{W})$ of open star cluster.
7. The solar apex parameters $(\text{i.e. } l_A,\ b_A \text{ and } S)$.

Results could be shown in Table 2.

## DISCUSSION AND CONCLUSION

Depending on convergent point and error controlled methods, with computational algorithm that designed by Sharaf et al. (2000), we focused here on some aspects of the 74 members of Rp147 moving open cluster. We computed many aspects of Rp147, like, vertex coordinates, velocity, distance, distance modulus, and center of cluster … etc.

**Table 2.**Our characteristics of Rp147

| Character | Value |
|---|---|
| $(A,D)$ | $85.925^o \pm 1.691, 78.774^o \pm 2.379$ |
| $V(km/s)$ | $48.393 \pm 2.570$ |
| $d(pc)$ | $163.982 \pm 20.117$ |
| $(m-M)$ | $6.074$ |
| $(x_c, y_c, z_c)_{pc}$ | $51.555, -149.401, -46.409$ |
| $(\overline{X}, \overline{Y}, \overline{Z})$ | $10.684, -33.688, -33.014$ |
| $(\overline{U}, \overline{V}, \overline{W})$ | $44.811, -4.397, -17.651$ |
| $l_A$ | $5.604^o$ |
| $b_A$ | $21.406^o$ |
| $S(km/s)$ | $48.362$ |

- The distance have been computed and compared with others, but there is a difference with others, for that, we can focusing on Kharchenko et al. (2005), he able to determine an age (2.45 Gyr) from the MSTO (Main Sequence Turn Off) consistent with the results of our analysis, the (B−V) main sequence is dominated by photometric error and therefore provides a weak constraint on the distance, which their isochrones fitting has apparently placed 125 pc too close, at 175 pc compared to the 163.982±20.117 pc we find here.
- Distance modulus (m-M) of Rp147 was computed and compared with other, which represent good agreements.
- The components of the space velocity along *x, y* and *z* axes have been computed, and similarly for the galactic space coordinates.
- Moreover, we have computed the parameters of the solar motion.

Table 3, indicates that the values are in good agreement due to comparison with other published values.

**Table 3.**Comparison with other published values of Rp147

| Character | Value | Ref. |
|---|---|---|
| $V(km/s)$ | 40.7 | Curtis et al. (2013) |
| | $44 \pm 3$ | $RV_{LP}$ (Lick, Palomar), Curtis et al. (2013) |
| | $41.6 \pm 1.5$ | $RV_{H}$ (Hectochelle), Curtis et al. (2013) |
| | 40.5 | Pakhomov et al. (2009) |
| | 41 | Kharchenko et al. (2005) |
| | 41 | Dias et al. (2001) |
| | 41 | Wilson (1953) |
| $d(pc)$ | $295 \pm 15$ | Curtis et al. (2013) |
| | $280 \pm 100$ | Pakhomov et al. (2009) |
| | $174 \pm 35$ | Wu, Zhen-Yu et al. (2009) |
| | 175 | Kharchenko et al. (2005) |
| | 200 | Dias et al. (2002) |
| | 270.27 | Dias et al. (2001) |
| $(m-M)$ | $7.35 \pm 0.1$ | Curtis et al. (2013) |
| $(\overline{U}, \overline{V}, \overline{W})$ | $53.3, 218.0, -11.1$ | Wu, Zhen-Yu et al. (2009) |

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