# The period of Fr151 Cyg = GSC 03949-01097

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**Abstract:** *The variability of Fr151 Cyg was discovered by Peter Frank in 2011, who classified it as an eclipsing binary. The authors published the discovery in 2019 in BAVJ No. 27. The authors present phased light curves from ASAS-SN and their own data, a list of primary and secondary minima, O-C-diagrams and an improved period solution of the star.*

## Observations

400 mm ASA Astrograph f/3.7 - f = 1471 mm, FLI Proline 16803 CCD-Camera - V-filter - t = 120 sec.
Wolfgang Moschner, Astrocamp/Nerpio, Spain
102 mm f/5.0 TeleVue Refractor - f = 509 mm, SIGMA 1603 CCD-Camera, Kodak KAF1603ME,
IR & UV cut-off filter, t = 90 sec., Peter Frank, Velden, Germany

## Data analysis

Muniwin [1] and self-written programs by Franz Agerer and Lienhard Pagel [2] were used for the analysis of the frames, after bias, dark and flatfield correction. The weighted average of 5 comparison stars was used.

**Explanations:**
HJD = heliocentric UTC timings (JD) of the observed minima
All coordinates are taken from the Gaia DR3 catalogue [3]. The coordinates (epoch J2000) are computed by VizieR, and are not part of the original data from Gaia (note that the computed coordinates are computed from the positions and the proper motions).

# Fr151 Cyg

Cross-IDs
**= ASASSN-V J201726.52+591257.0**          **= UCAC4 747-061302**
**= ATO J304.3605+59.2159**          **= 2MASS J20172651+5912571**
**= Gaia DR3 2236610442804206208**          **= USNO-A2.0 1425-10507446**

Gaia DR3 catalogue:
Right ascension: 20h17m26.5126s at Epoch J2000
Declination: +59° 12' 57.117"      at Epoch J2000
13.0495 mag   G-band mean magnitude (350-1000 nm)
13.4467 mag   Integrated BP mean magnitude (330-680 nm)
12.4833 mag   Integrated RP mean magnitude (640-1000 nm)
0.9634   mag   BP-RP

## Periods known so far:

| | | | |
|---|---|---|---|
| VSX [4] | 2.0777543 d | ATLAS [6] | 2.077878 d |
| ASAS-SN [5] | 4.1550327 d | | |

## Results

The variability of Fr151 Cyg was discovered by Peter Frank in 2011, who classified it as an eclipsing binary. The authors published the discovery with a first period in 2019 in BAVJ No. 27 [7] and suspected that the period could also be twice as long. Further observations up to 2023 confirmed this assumption. Furthermore, in the extended O-C-diagram we now see a period change after the year 2018. The improved period applies to the time from the beginning of the observations to the beginning of the period change. It is exactly twice the period published by the authors in BAVJ No. 27. Min. I and Min. II are the same depth within the observation accuracy.

The VSX database, the ASAS SN variable stars database and the ATLAS database also list the star as variable, but with different periods. The variable is not listed in the SIMBAD database [8], the ZTF project [9] or the WISE project [10].

The presented improved elements were calculated by the method of least squares, taking into account the minima between JD 2455834 to 2458406 (see table below) and assuming that the true phase of Min. II is exactly at 0.5. We had 5945 of our own data points available for our analysis.

The authors will continue to observe the variable over the next few years in order to calculate the period for the period after the period change. At present, the data are not yet sufficient for this.

From our data (Figure 1) we derive a variability approx. between 13.26 and 13.74 mag, with an amplitude for Min. I given as 0.50 mag and for Min. II as 0.48 mag (Filter -I-U). Our observations show a period change after the year 2018.

## Fr151 Cyg    improved elements

Type    =    EA
Min. I    =    HJD 2455834.3880  + 4.1555090*E
                    ±0.0019   ±0.0000030

| Observer | HJD-Date Minimum | Type | Epoch | O-C (d) | Remarks |
|---|---|---|---|---|---|
| P. Frank | 2455834.3880 | I | 0 | 0.0000 | |
| P. Frank | 2456933.5196 | II | 264.5 | -0.0005 | |
| Moschner/Frank | 2457249.3400 | II | 340.5 | 0.0012 | incomplete |
| Moschner/Frank | 2457278.4274 | II | 347.5 | 0.0000 | |
| P. Frank | 2457625.4111 | I | 431 | -0.0013 | |
| Moschner/Frank | 2457924.6074 | I | 503 | -0.0016 | |
| P. Frank | 2458406.6497 | I | 619 | 0.0016 | |
| W. Moschner | 2459792.5022 | II | 952.5 | -0.0081 | |
| W. Moschner | 2459819.5092 | I | 959 | -0.0120 | |
| W. Moschner | 2460268.3025 | I | 1067 | -0.0136 | |

Table 1:  Minima of Fr151 Cyg = GSC 03949-01097 using the elements from the authors.
The O-C of the secondary minima were calculated assuming that the true phase is at exactly at 0.5.
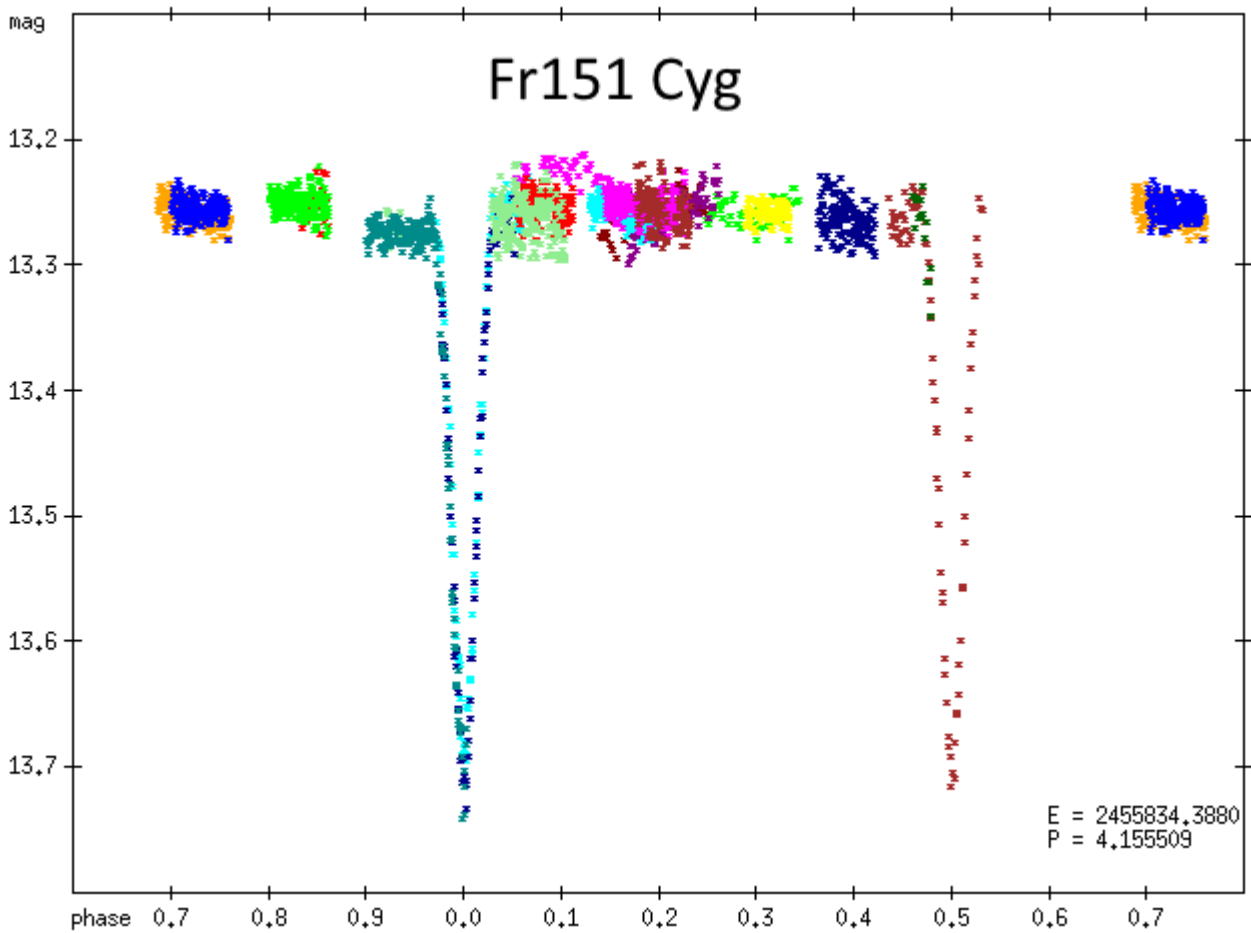
Figure 1: Phased light curve of Fr151 Cyg = GSC 03949-01097 using the ephemeris given by the authors. The vertical axis shows uncalibrated V magnitudes. Different colors denote different observing nights. A SIGMA 1603 CCD-Camera camera + IR & UV cut-off filter was used. The light curve in maximum light was supplemented by data from a FLI Proline 16803 camera + V-filter. These data were corrected by the filter offset. The brightness values shown therefore refer to the IR & UV cut-off filter.
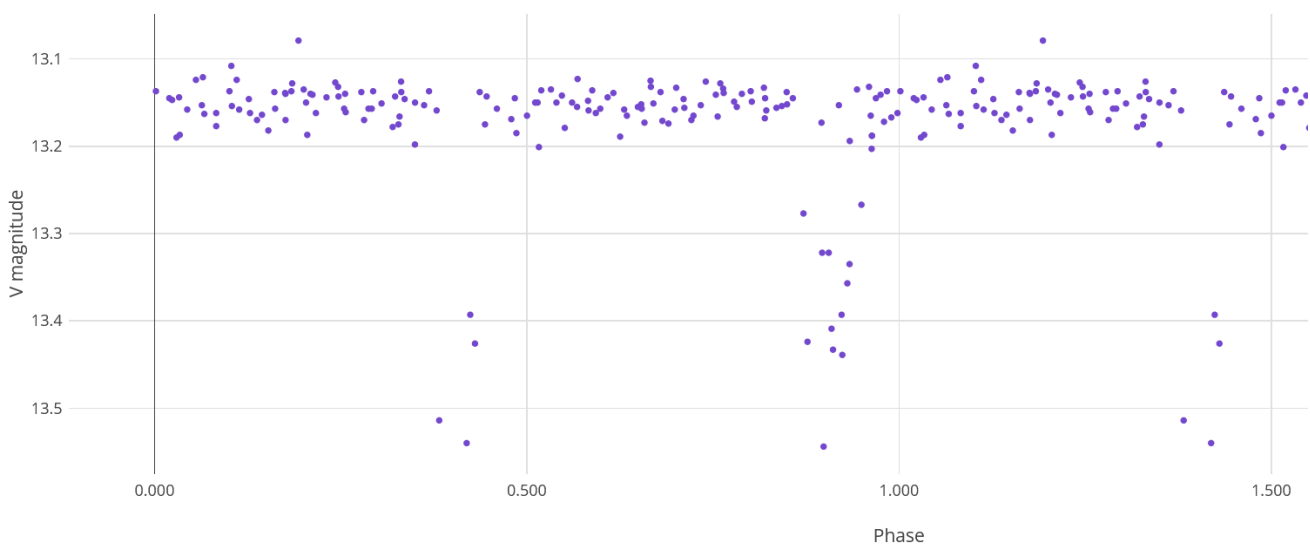


Figure 2: Phased light curve of Fr151 Cyg = GSC 03949-01097 using the period and data (V-Band) from ASAS-SN. This graphic is taken from the ASAS-SN website.
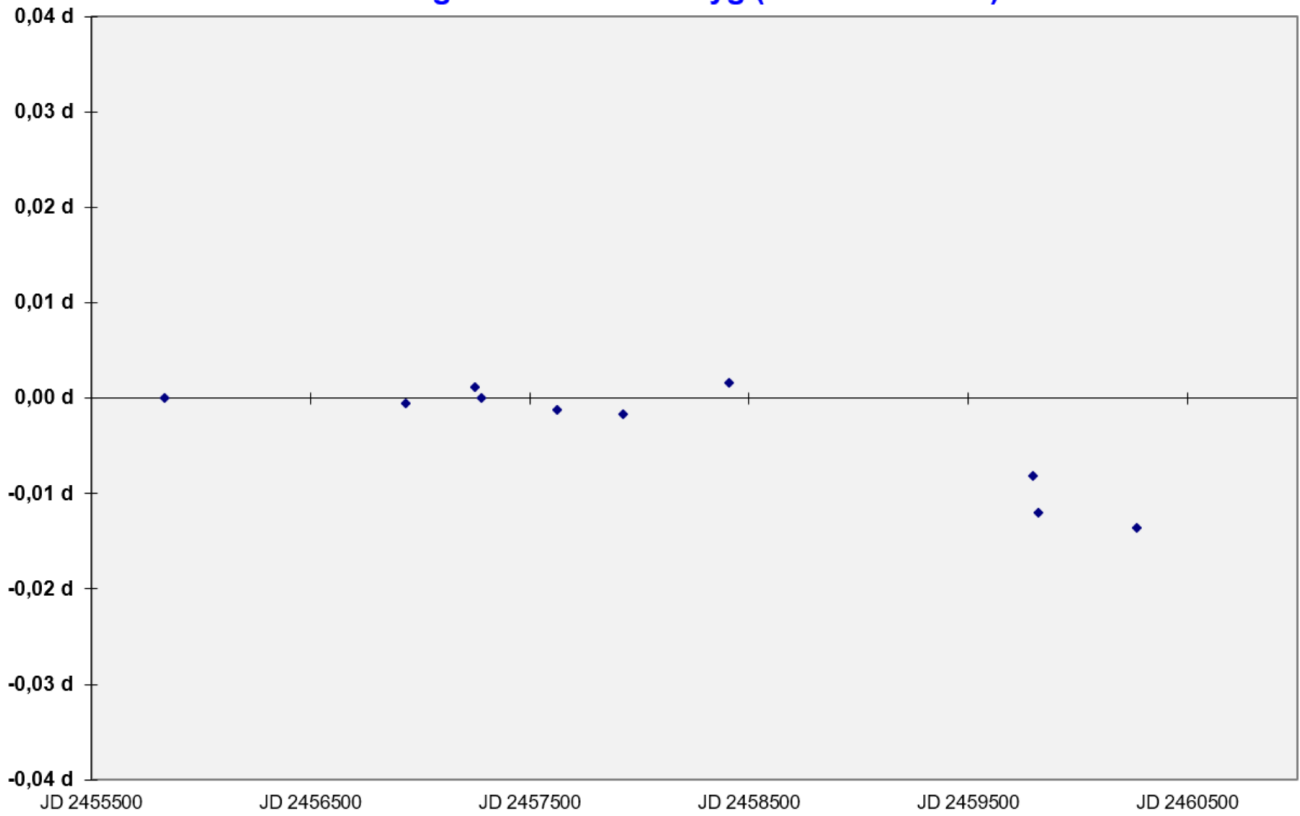
Figure 3: O-C-diagram of Fr151 Cyg = GSC 03949-01097 using the improved ephemeris from the authors. These CCD minima between 2011 and 2018 were used to calculate the period.
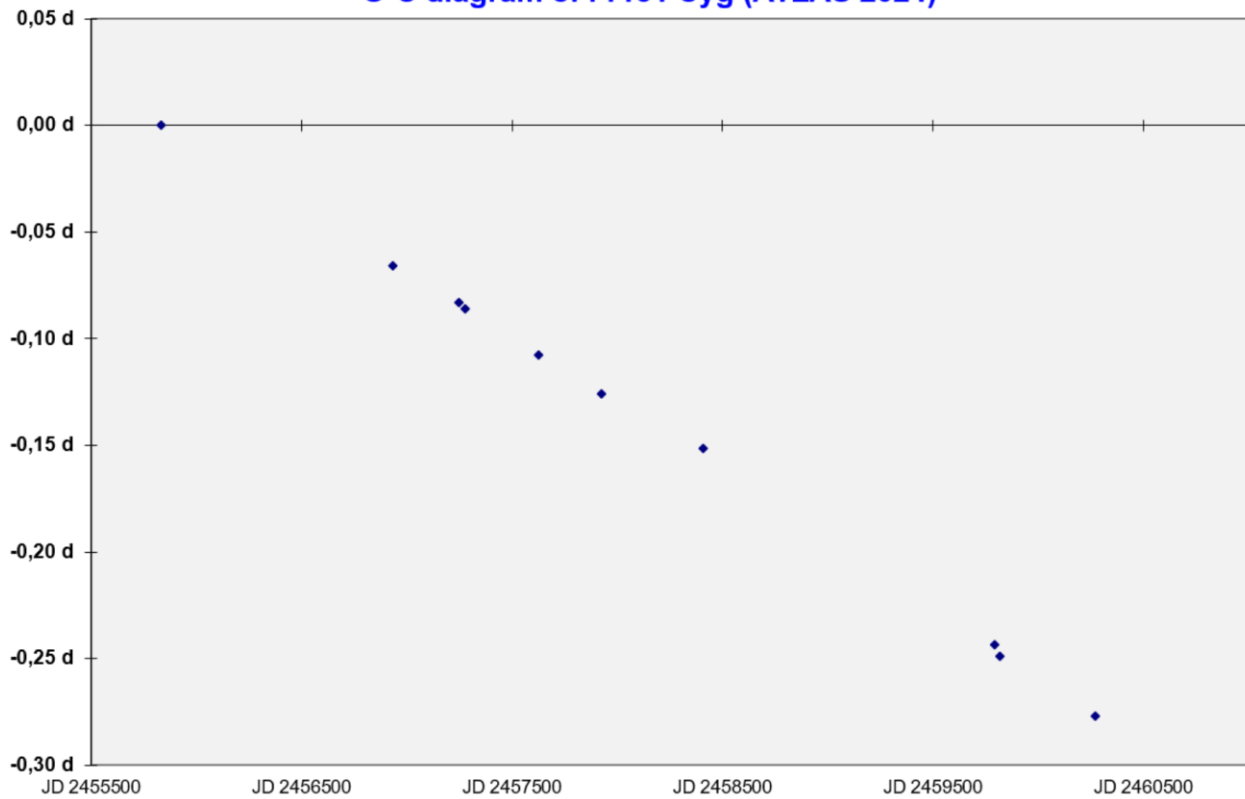


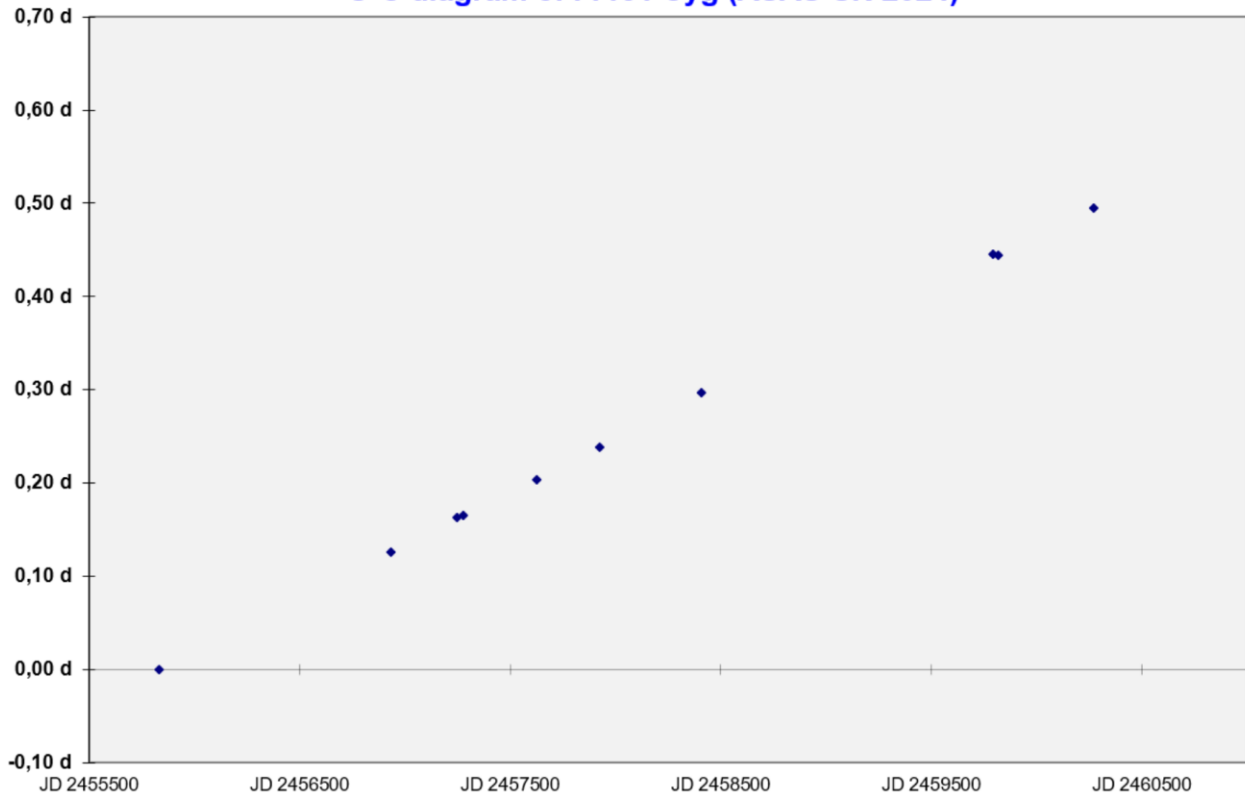Figure 4: O-C-diagram of Fr151 Cyg = GSC 03949-01097 using the period from the ATLAS project (2.077878 d).

Figure 5: O-C-diagram of Fr151 Cyg = GSC 03949-01097 using the period from the ASAS-SN project (4.1550327 d).

## Acknowledgements

## References

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[2] Pagel, Lienhard: Starcurve
https://www.bav-astro.eu/index.php/weiterbildung/tutorials

[3] Gaia DR3 (Gaia Collaboration. 2020) European Space Agency.
http://vizier.u-strasbg.fr/viz-bin/VizieR?-source=I/355

[4] The International Variable Star Index (VSX)
https://www.aavso.org/vsx/index.php?view=search.top

[5] All-Sky Automated Survey for Supernovae ASAS-SN
http://www.astronomy.ohio-state.edu/asassn/index.shtml
Shappee et al., 2014, ApJ, 788, 48S
https://ui.adsabs.harvard.edu/abs/2014ApJ...788...48S
Jayasinghe et al., 2019, MNRAS, 485, 961J
https://ui.adsabs.harvard.edu/abs/2019MNRAS.485..961J:

[6] A first catalog of variable stars measured by ATLAS (Heinze+, 2018)
http://vizier.u-strasbg.fr/cgi-bin/VizieR-3?-source=J/AJ/156/241/table4

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https://www.bav-astro.eu/images/Up_Journal/_Find/BAVJ027.pdf

[8] SIMBAD Astronomical Database - CDS (Strasbourg)
http://simbad.u-strasbg.fr/simbad/sim-coo?Coord=20%3A17%3A27+%2B59%3A12%3A57&CooFrame=FK5&CooEpoch=2000&CooEqui=2000&CooDefinedFrames=none&Radius=2&Radius.unit=arcmin&submit=submit+query&CoordList=

[9] ZTF Zwicky TransientFacility, Systematic Exloration of the Dynamic Sky
https://www.ztf.caltech.edu/

[10] WISE catalog of periodic variable stars (Chen et al., 2018)
J/ApJS/237/28/table2