EURASIAN PHYSICAL TECHNICAL JOURNAL

2025, Volume 22, No.2 (52)

https://doi.org/10.31489/2025N2/155-162

Received: 25/01/2025 Revised: 23/04/2025 Accepted: 20/06/2025 Published online: 30/06/2025

Original Research Article

UDC 53.01

STUDY OF BRIGHTNESS VARIATIONS OF IRAS 07080+0605 FROM THE ASAS SN DATA

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Abstract. *This paper presents the findings of an analysis of the light curve of the star IRAS07080+0605, a member of the FS CMa class. The analysis was conducted using data from the ASAS-SN survey, collected between 2014 and 2025. The year-by-year analysis of the ASAS-SN time series in the g filter reveals that the system's period changes over time, and the shape of the phase curve varies during individual intervals. The asymmetry observed in the phase curves suggests potential orbital changes, possibly related to the system's dynamics, including variations in the separation between the components. Additionally, we describe changes in the luminosity amplitude of IRAS07080+0605, which may reflect alterations in the star's physical state, such as pulsations in its outer layers or interactions with its environment.*

Keywords: binary systems, light curves, FS CMa, catalog ASAS SN

1. Introduction

The FS CMa-type objects that exhibit the B[e] phenomenon were first distinguished as a distinct evolutionary group in [1]. The B[e] phenomenon is characterized by the presence of both allowed (Balmer lines, Fe II, and others, and forbidden ([Ca II], [O I], and others) emission lines in the spectra of stars with surface temperatures ranging from ~10000 to ~30000 K (formerly classified as B-type stars) and a significant excess of IR emission relative to the expected stellar emission, attributable to the presence of circumstellar dust. The most probable scenario for the formation of FS CMa objects [1], according to the confirmed existing data [2] as well as the results of analyses, is the evolution of a close double system in which there is a strong mass transfer between the components of the double system, leading to the loss of some of this mass into the circumstellar space and the formation of a dust shell or disc.

Recent studies have made significant progress in the research of FS CMa-type stars. Through detailed and comprehensive analyses of long time series of observations, new properties of this group of stars have been discovered, including rapid spectral variations [3] and the presence of lithium lines in the stellar spectrum [1, 4]. Furthermore, orbital periods have been determined for a number of objects in this group [4, 5], the physical characteristics of the system components have been described [6], and key physical parameters of the stars have been determined [6]. These studies have revealed a wide range of luminosities among these objects, suggesting the existence of numerous such systems both in our galaxy and in others. The observed strong IR excesses indicate that FS CMa group objects represent a previously unrecognized source of dust in the galaxy. These objects have not previously been considered dust producers, and a reassessment of Galactic dust production is necessary.

Considerable attention has been devoted to the study of hot stars surrounded by circumstellar material, particularly in binary systems and during late evolutionary phases such as the post-AGB stage. These investigations have revealed a broad diversity in photometric and spectroscopic behavior, strongly influenced by dynamic interactions within the system and the structure of the surrounding envelope. For instance, [7] Zharikov et al. (2025) analyzed the FS CMa-type candidate IRAS 17449+2320, identifying a complex circumstellar environment affected by a variable magnetic field and orbital modulation, suggesting strong binary interaction and non-uniform envelope morphology. Similarly, [8] Ikonnikova et al. (2025) examined the post-AGB star IRAS 21546+4721, reporting cyclic photometric variability and spectroscopic changes indicative of pulsations and variable extinction from circumstellar dust. On a broader scale, [9] Kwok (2025) provided an in-depth theoretical review of chemical synthesis in stellar envelopes, emphasizing how mass-loss and outflow processes contribute to the development of molecular complexity in the circumstellar medium. These studies further demonstrate the importance of long-term photometric monitoring for identifying instability mechanisms and interpreting the evolutionary status of stars with extended envelopes.

This work is devoted to the study of the star IRAS 07080+0605 (a northern hemisphere object), which has one of the strongest IR excesses among objects with the B[e] phenomenon. This object was first identified as an emission star in [10], in a survey of stars with emission lines.

There are conflicting opinions on the conclusions about the nature of the object. In [11,12], the object IRAS 07080+0605 is considered to be a pre-main-sequence star. However, in a recent paper [13], it was concluded that the object IRAS 07080+0605 satisfies the observational and physical criteria for the FS CMa and a suggestion that it could be an analog of Red Rectangle at an early evolutionary stage.

There are also a number of works on the study of the variation of the light of this object, but the values of the period are different. In [12], the authors discovered multiple periods through the analysis of the periodogram of the ASAS-SN survey data, with a particular focus on the most reliable ones: 72.1, 248.8, and 203.1 days. A similar period of 246.7 days was determined in [11] using ASAS-3 survey data [14].A recent study [13] on an individual study of the object IRAS 07080+0605 also suggested a period of ~190 days, but it was noted that this period was not revealed in the 2014 and 2019 seasons. The period value was derived from data from the ASAS-SN survey from the 2014 to 2019 seasons only. In this paper, the authors noted that the ASAS-SN survey data [15] was used to find the period because it has less error compared to the ASAS-3 survey data. However, the photometric survey data for the most recent observing period (up to 2025) from the ASAS-SN survey, when stacked with the above periods from both [13] and [11,12], show a very large dispersion around the mean sinusoidal curves (see the Analysis Results section). Therefore, one can conclude that the light curve behavior is ambiguous.

The primary objective of this study is to analyze the light curve of the object IRAS 07080+0605. This analysis builds upon the findings of previous studies, including those presented in [13], which covered the period up to 2019. In this work, we utilize the most extensive and comprehensive set of observational data on the object's luminosity available to date.

Study is based on the data from the All-Sky Automated Survey for Supernovae (ASAS-SN), a photometric monitoring project launched in 2013. The ASAS-SN program began regular accumulation of high-quality optical photometry in mid-2014. From this period onward, the data series provides sufficient temporal coverage, uniform cadence, and photometric accuracy to allow robust analysis of long-term brightness variations. For this reason, our analysis covers the time range from 2014 to 2025, encompassing the full available span of precise ASAS-SN photometric observations.

2. Observational data and methods for analyzing the star's luminosity

ASAS-SN photometric data were used in this paper. The ASAS-SN survey data cover the period from half of 2014 to 2025. The survey data from 2018 were observed in the g filter and were converted to the Johnson-Cousins system filter V using formula 1, according to the work of [16]. The mean value of (B-V) = 0.12 was taken from [13]. The rationale for the choice of ASAS-SN survey data is due to the fact that the ASAS-3 data are strongly inferior to the ASAS-SN data. The light curve derived from ASAS-3 data (see Figure 5 in [13]) exhibits significant noise and errors, likely caused by larger uncertainties in brightness measurements.

$$V = g' - 0.54(B - V) + 0.07$$

The Lomb-Scargle Periodogram method [16] is used to analyse time series in this paper. The Lomb-Scargle method is particularly useful for analysing non-uniformly distributed time series, where traditional methods of frequency analysis, such as the discrete Fourier transform, are inapplicable due to the need for uniform data sampling. This makes it an indispensable tool for working with astronomical observations, which are often characterised by irregularity. The algorithm implemented on the website [17] was deployed to search for the period.

3. Results

The ASAS-SN survey data in the g filter were selected for analysis to ensure the optimal homogeneity in timeliness of the observations, as evidenced by the reduced number of areas lacking observations in this band when compared to those in band V (see Figure 1, upper panel). The long-term trend was subtracted for this band (see Figure 1, bottom panel). The trend removal procedure entailed the following steps:

– For each observation season, the mean JD values and the brightness value were calculated;

– Subsequently, coefficients were calculated from these mean points, as well as spline values for each real JD value.

– The difference between the lightness value and the spline was determined, resulting in a series with a subtracted trend.

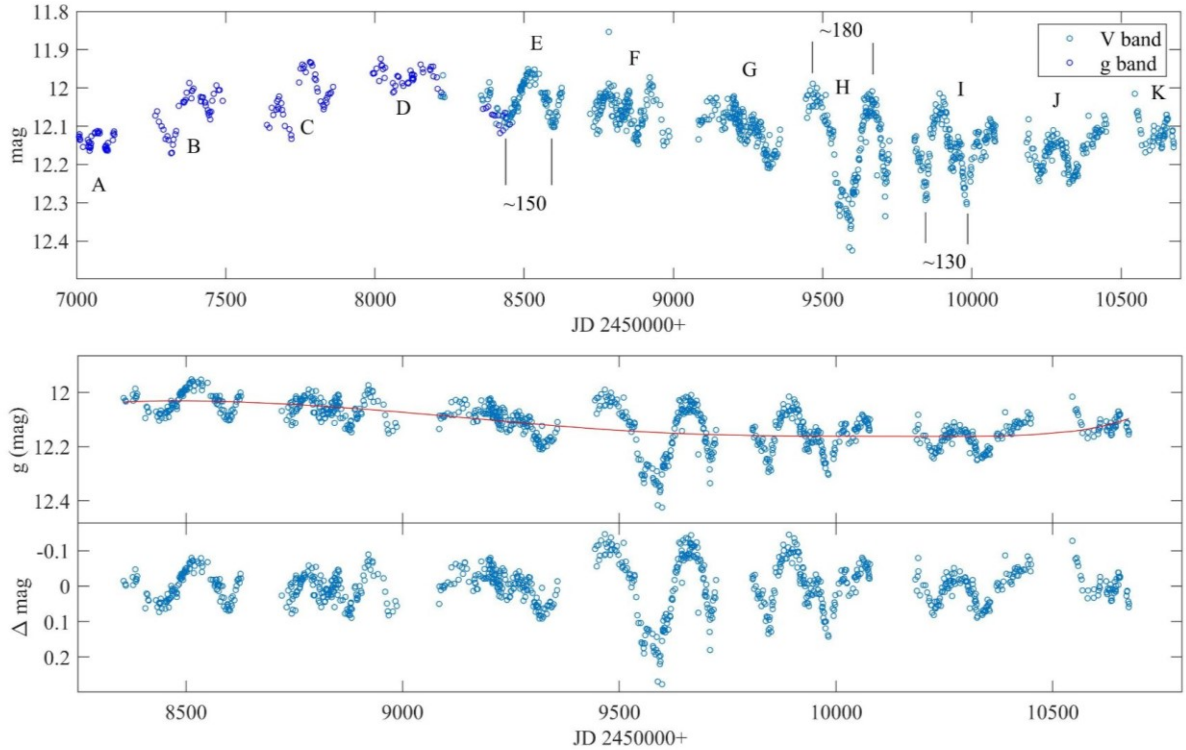

Fig. 1. Light curve of the IRAS 07080+0605 system from the ASAS SN data. The upper panel shows brightness variations IRAS 07080+0605 in 2014–2025 from the ASAS SN data. The middle panel shows the light curve with the actual data (open circles) and the running average (red line) used to determine the brightness trend. The bottom panel shows a detrended g-band brightness with respect to the running average

As demonstrated in Figure 2 (bottom panel), the Fourier power spectrum indicates a peak at approximately 125 days. The phase curve, convolved with this period, displays a substantial spread of approximately 0.2 magnitude.

The ASAS-SN survey data in the g filter were analyzed using the previously proposed periods of approximately 72, 190, 203, and 250 days. The results of this analysis indicated that none of these periods produced consistent phase curves, instead resulting in significant scatter.

However, when constructing phase curves for individual intervals, as indicated by the letters in the upper panel of Figure 1, different periods were observed. These periods (cycles) were found to be similar in both shape and amplitude. Despite this, the intervals exhibit clear periodicity. For instance, the light curves of interval H show a periodicity of approximately 180 days, as illustrated by the phase curve in Figure 3, which displays a clear minimum and maximum.

Therefore, a range of potential values for the period (cycle) is observed. The determination of the precise nature of these values is challenging, as evidenced by the dispersion in the phase light curves. In spite of this, the periods defined on a wide data sample may vary from season to season (time domains of observations without significant gaps) and practically vary within a particular season. For instance, the time domain 'H', as illustrated in the top panel of Figure 1, shows a difference between maximum peaks of ~180 days and minimum peaks of ~120 days. The LS method periodogram calculation, which indicates the largest power spectrum, is achieved through convolution with a period value of 171.9 days.

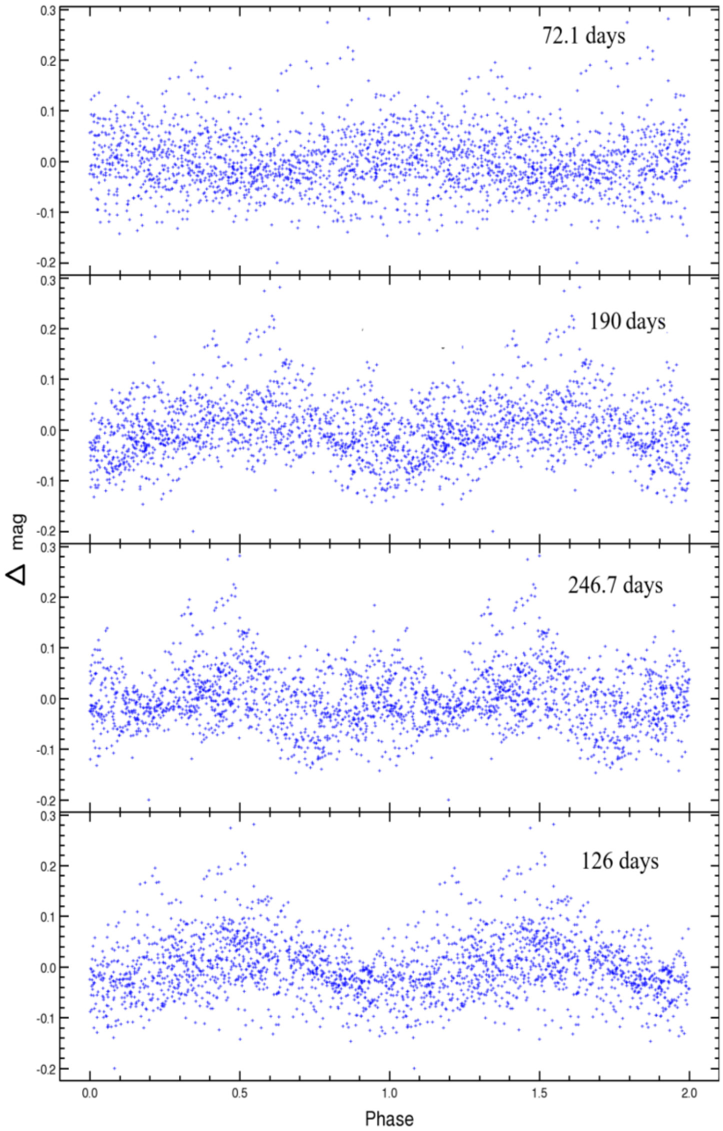

Fig. 2. The curves are convolved with the indicated periods based on the entire data sample between 2014 and 2025 in bands V and g from the survey data.

The behavior described above may suggest the presence of a quasi-periodic process with variable amplitude occurring in the dust disk, or alternatively, it may indicate a possible change in orbit, which may be related to the dynamics of the system, including changes in the separation between objects. In order to investigate the temporal changes in the stellar magnitude of the object, data containing corrected stellar magnitudes and their associated errors were analyzed.

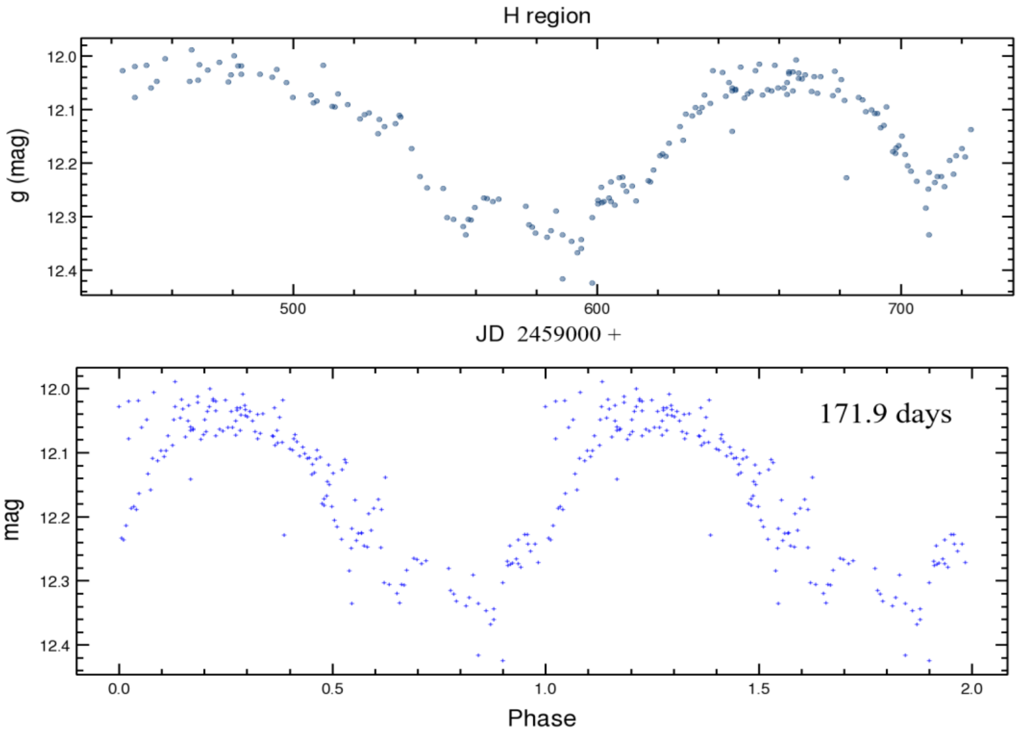

Fig. 3. Light curve in the g filter (upper panel) and the corresponding phase curve convolved with a period of 171.9 days.

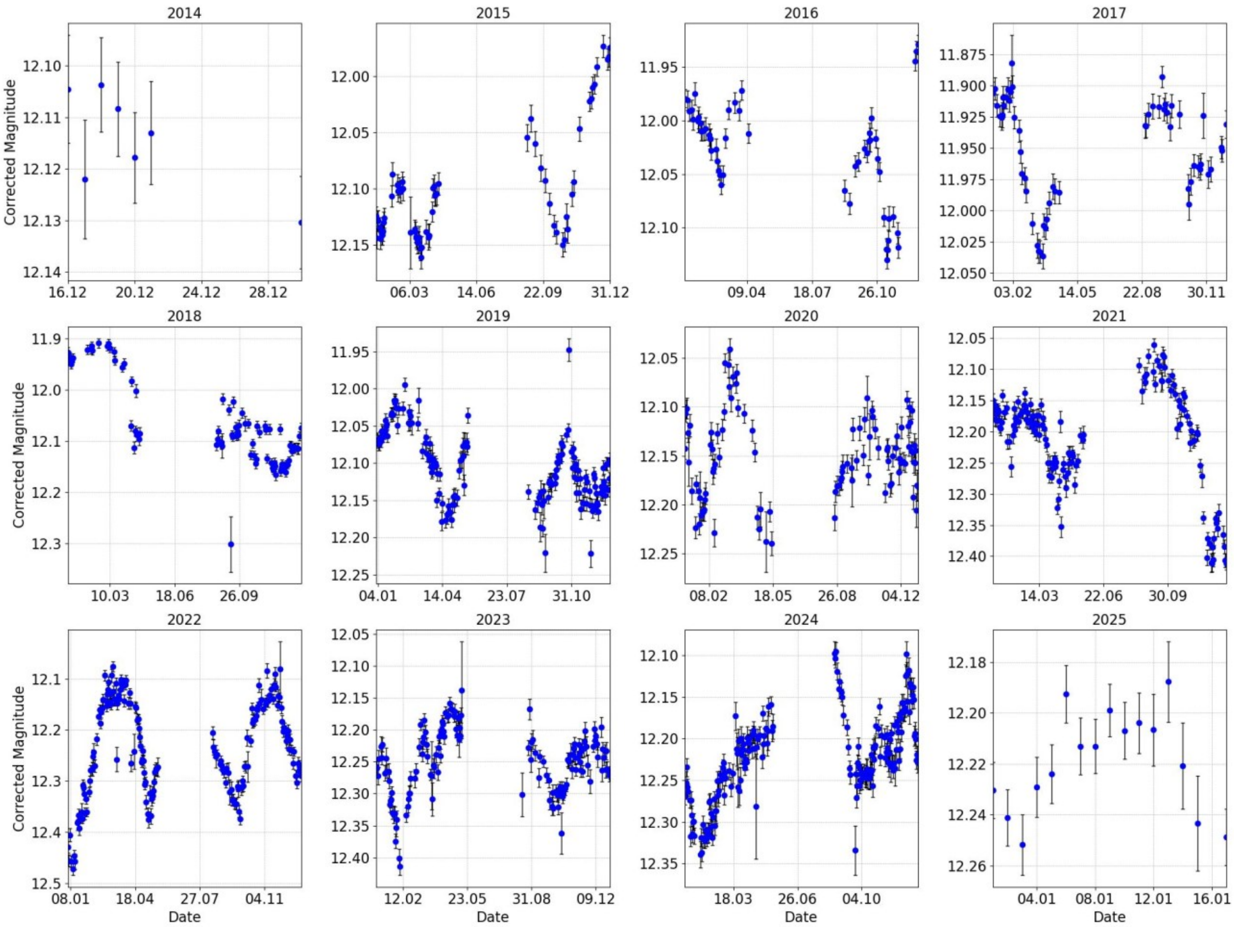

Fig. 4. Changes in the stellar magnitude of the object from 2014 to 2025.

The initial processing included the exclusion of anomalous points. Then, for each year and half-year, the mean signal amplitudes were calculated based on the difference between the minimum and maximum values of the correlated magnitude for the specified time interval. In order to obtain a visualization of temporal changes, the dependence of the mean corrected stellar magnitudes on time was plotted, with the errors of the data considering. The data were grouped by years and visualized in a separate subgraph for each year, thus allowing general trends in the object brightness variations to be identified and possible long-period variations to be estimated. Special attention was paid to the exclusion of incorrect data and anomalies, as well as to the respect of scales in order to facilitate the comparison of plots between years.

A more detailed analysis of changes in the object luminosity amplitude by season was conducted, whereby the average amplitudes for each half-year were calculated. To this end, the data were divided into time intervals depending on the season, and the amplitude values were calculated as the difference between the maximum and minimum mean luminosity values in each half-year. Furthermore, for each amplitude, the error was estimated on the basis of the statistical properties of the sample.

The visualization process involved the utilization of smoothed curves, which were obtained through the implementation of spline interpolation. This methodological approach facilitated the construction of a smooth plot, which depicted the trend of amplitude change over time. This trend revealed long-period variations. Moreover, the original measured values were plotted alongside their respective errors. This methodological approach was adopted to emphasize the validity of the calculations.

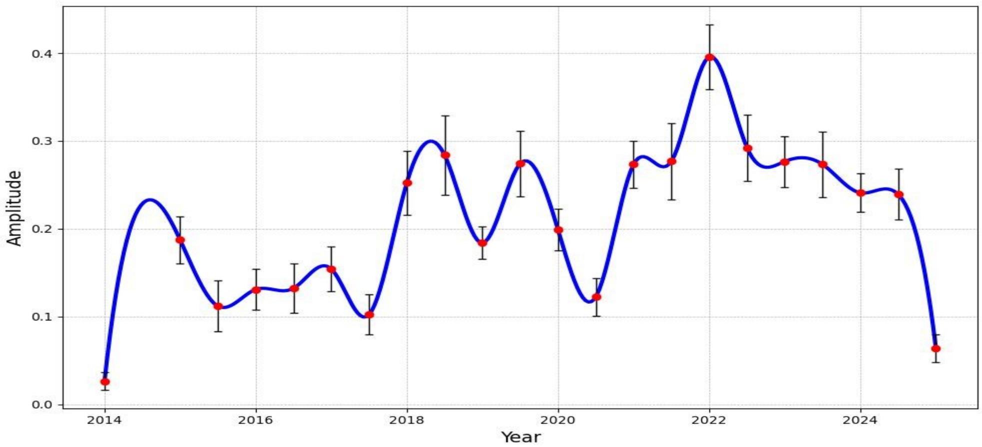

Fig. 5. Long-period changes in the amplitude of stellar magnitude.

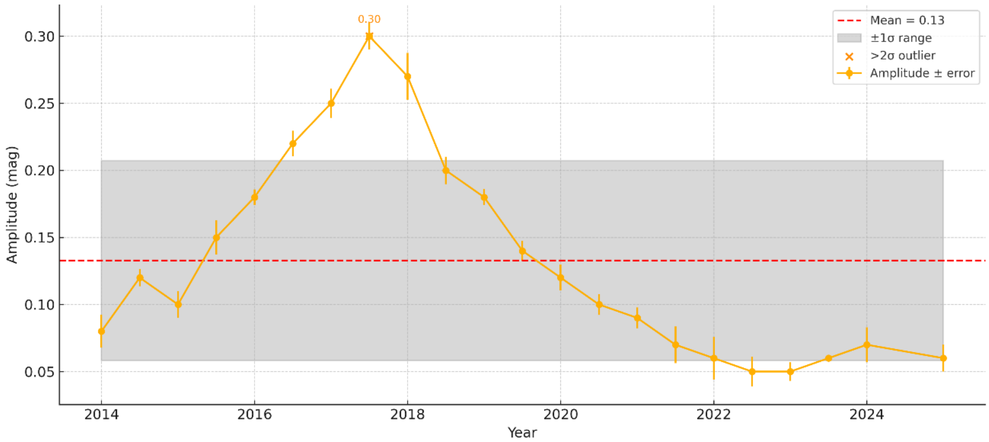

Fig. 6. Estimated amplitude of brightness variations of IRAS 07080+0605 between 2014 and 2025 based on ASAS-SN data. The red dashed line indicates the mean amplitude (~0.13 mag), and the shaded gray area represents the ±1σ confidence interval. Orange points mark outliers exceeding 2σ from the mean, which may reflect significant physical variability in the system, such as changes in pulsation activity or circumstellar dust properties. Error bars correspond to the standard photometric uncertainty for each data point.

The graph illustrates variations in the luminosity amplitude of a star believed to be in the post-AGB transition stage. These fluctuations may reflect changes in the star's physical state, such as pulsations of the outer layers or interactions with the surrounding environment. Periods of increased amplitude may be attributable to enhanced pulsations or changes in the composition and temperature of the star's atmosphere. Smoothed long-period trends may indicate global processes, such as changes in the envelope mass or the gradual decay of the star's activity during this stage of evolution.

4. Conclusion

This paper presents an analysis of time series separated by years, revealing that the period of the system changes over time and the shape of the phase curve undergoes changes at individual intervals. In particular, the appearance of asymmetries in the phase curves indicates possible orbital changes that may be related to the dynamics of the system, including changes in the separation between objects. In the late stages of evolution, such as the transition to post-AGB, a significant amount of mass can be lost through stellar wind, affecting the orbital parameters, including the system momentum, momentum and orbital eccentricity.

The presence of instabilities in the data may result from mass-loss processes and stellar pulsations, as well as the effects of dynamical interactions within the system. During specific time intervals, an uneven distribution of the data is observed, which could indicate the influence of additional factors, such as surrounding matter or complex interactions between the star and its companion.

Furthermore, the role of the circumstellar environment in shaping the photometric behavior of IRAS 07080+0605 should be emphasized. The presence of a non-uniform dust disk and extended envelope likely contributes to the observed light curve asymmetries and amplitude variations. Variable extinction, scattering, and potential interactions with a companion star may account for both short-term irregularities and long-term trends. These effects highlight the need for complementary studies to fully understand the dynamical structure of the system.

The detected photometric instabilities are most likely driven by a combination of stellar pulsations and dynamic interactions within the system. These mechanisms, typical for evolved stars in the post-AGB phase, contribute to both variability in brightness and changes in phase curve morphology. Identifying and disentangling these contributions remains a crucial objective for future studies.

Additionally, the paper describes amplitude variations that may reflect changes in the physical state of the star, such as pulsations of the outer layers or interaction with the environment. In this context, an increase in amplitude may correlate with the lengthening of local periods within cycles. The smallest dispersion of light curve values from the full ASAS SN dataset from 2014 to 2025 minus the long-term trend is obtained by convolution with a period of 126 days.

Conflict of interest statement

The authors declare that they have no conflict of interest in relation to this research, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this paper.

CRediT author statement

Khokhlov A.A.: Conceptualization, Methodology, Supervision; **Agishev A.T.:** Investigation, Data curation, Writing - Review & Editing, Project administration; **Vaidman N.L.:** Formal analysis, Software, Visualization, Writing - Original Draft; **Agishev A.T.:** Validation, Resources.

Funding

This research was funded by the Committee on Science of the Ministry of Science and Higher Education of the Republic of Kazakhstan (grant AP19175392 of the Ministry of Education and Science of the Republic of Kazakhstan).

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