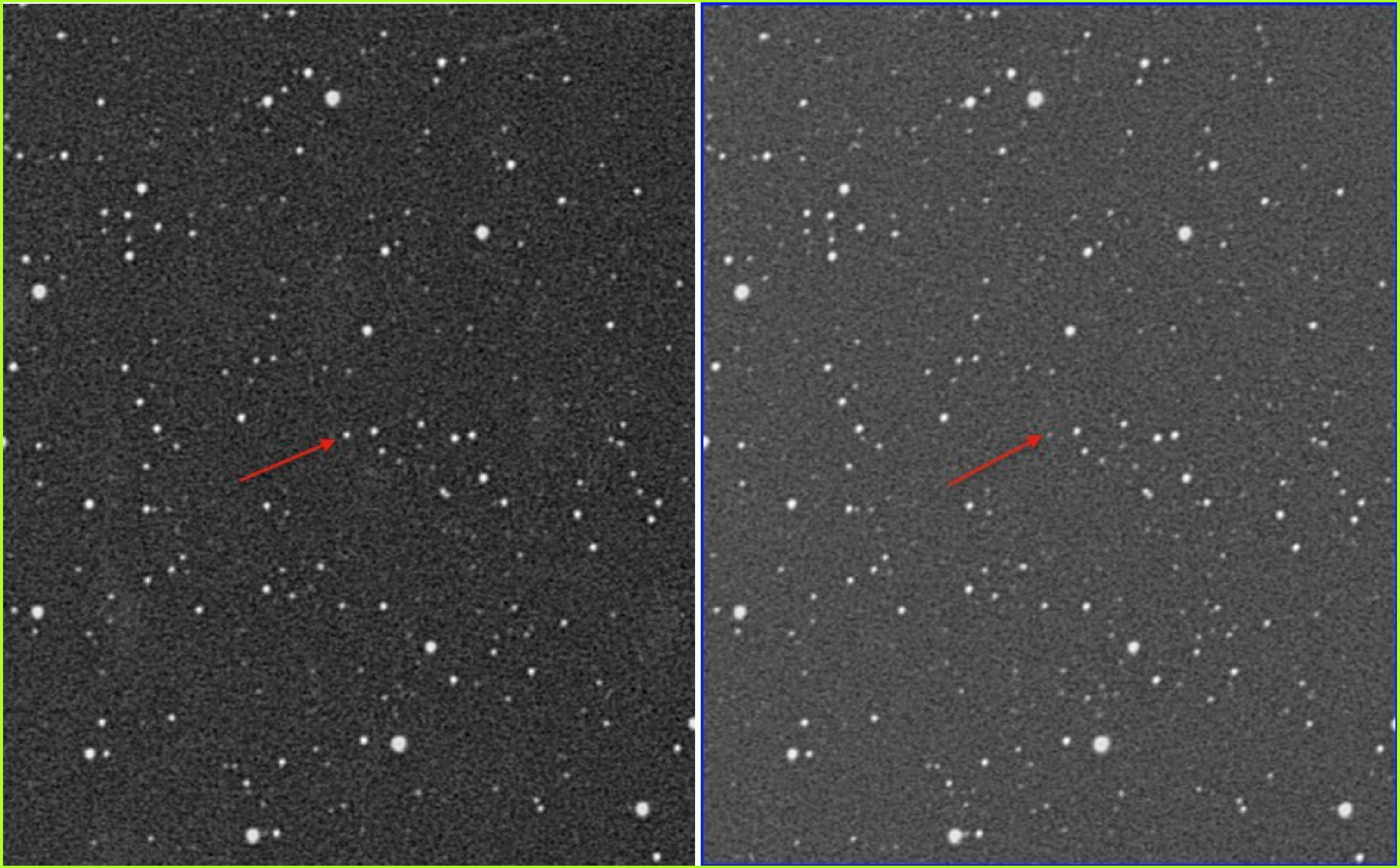
Records from the past



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Summary

The Asiago plate archive

Plate digitization

Search for Mira variables in Cassiopeia

Cataclismic variables

Asiago plate archive

The Asiago plate archive contains plates of four telescopes
The 122 cm Newton/Cassegrain
The 40/50 cm Schmidt
The 65/92 cm Schmidt
The 183 cm Cassegrain

The Schmidt telescopes have been used both in imaging mode and with objective prisms

The Newton focus of the 122cm telescope was used both in imaging mode and in low-resolution spectrographic mode. The Cassegrain focus was (and is) used only in spectrographic mode.

The 183 cm telescope is used in imaging and spectrographic modes.

A total of about 78000 plates are present.

Digitization

- A substantial number of plates have not still been digitized, due to lack of dedicated funding and manpower.
- Most of the plates have been scanned with an EPSON 1680 Pro, at 1600 dpi, or an EPSON 10000XL at 2400 dpi, in transparency mode, with 14 or 16 bit resolution.
- The scans were made in manual mode, with gamma=1 and selecting the maximum and minimum values from the grayscale histogram of the scan preview.
- Also the (unexposed) plate borders were kept well visible, so that the plate fog was measurable and the original plate number readable. Images were saved directly in FITS format.
- Logbooks are available as spreadsheets and can be downloaded from the Asiago website: http: //www.oapd.inaf.it/index.php/en/telescopes-and-instrumentations/archive-and-publication.html

Astronomical use

I will report here on two recent reseaches based on the Asiago archive:

1) a search for Mira variables in infrared plates centered on Gamma Cassiopeiae.
(Nesci, R.; Tuvikene, T.; Rossi, C.; Gaudenzi, S.; Galleti, S.; Ochner, P.; Enke, H. 2018, RMxAA, 54, 341)

2) a search for past outbursts of ASASSN-18aan, a cataclismic variable recently discovered by the ASASSN survey.
(Nesci, R., Tuvikene, T., Gualandi, R. 2019, submitted to IBVS)

Mira variables

A search for Mira variables along the Milky Way was started at Asiago by Paolo Maffei in 1967 using I-N hypersensitized plates + RG5 filter, and 103aO plates (with or without GG13 filter) taken on pair in the same night.
The time sampling was about two weeks, given that these stars have typical periods around one year.
The plates were taken with the large Schmidt (67/92/215) until 1975, with a few plates taken in the following years until 1984.

Four fields at different galactic longitudes were monitored, but only for 3 of them the discovered variables were published by Maffei and coworkers, after many years of patient work with microscopes, blink comparator, and eye estimate of the magnitudes.

Mira variables

I decided to explore the last unpublished field, centered on Gamma Cas at (l=123, b=-2) to see if undiscovered Mira variables were still present in the field, and to test the efficiency of discovery with automated techniques.

87 plates I-N plates were available for this field, with denser sampling in the first years. The plates were digitized at the Perugia University at 1600 dpi, with an EPSON 1680 Pro, one of the scanner models used also at the Asiago Observatory. This provides a sampling of 1.52 arcsec/pixel.

The candidate Miras were selected from the IPHAS survey catalog, a deep survey covering the galactic plane in three bands.

Two limits were applied to this catalog:
A magnitude limit $i < 16.5$ (the approximate Asiago plates limit);
A color limit $r-i > 1.7$ (all known Miras are redder than this).

About 530 stars were found on the Asiago plates, satisfying our magnitude and color limits.

Automatic search

The astrometric solution for each plate was computed with the PyPlate software, developed for the APPLAUSE project, allowing a very fast location of the candidates on each plate.

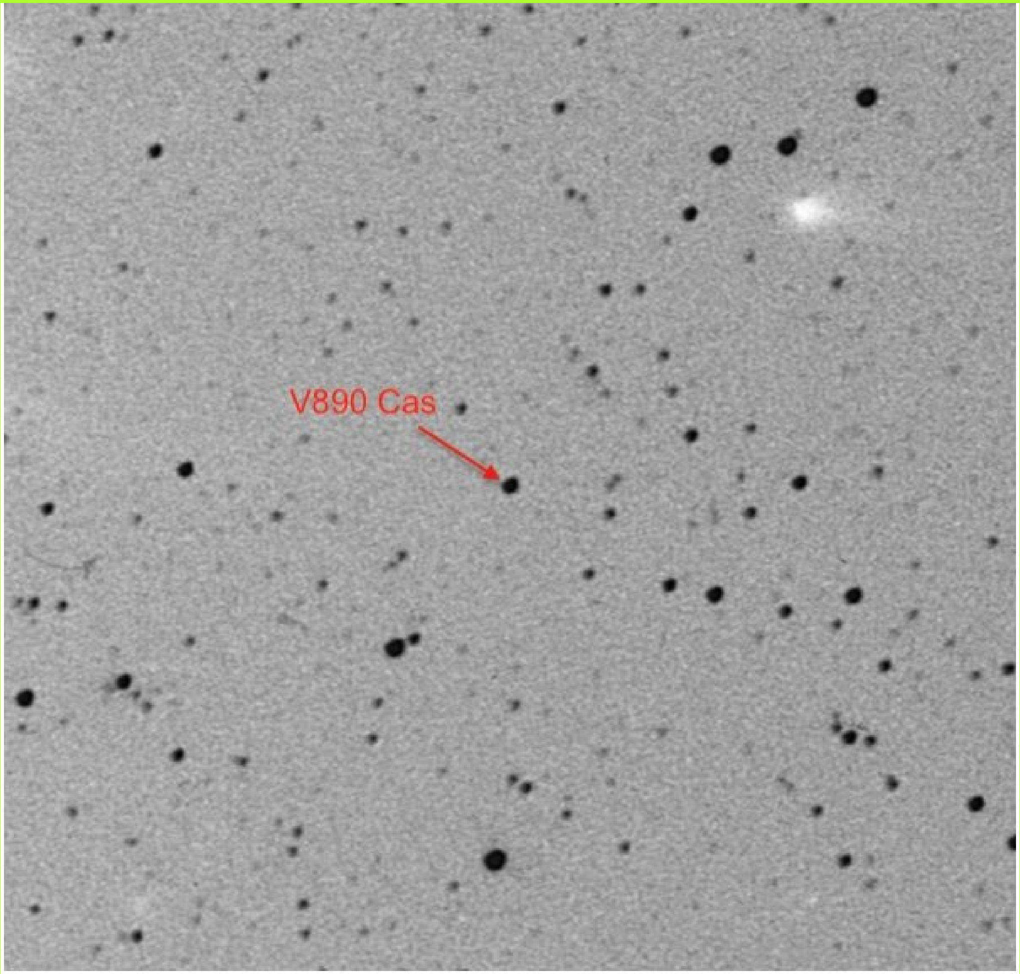
Instrumental magnitudes were computed with Sextractor (MAG_AUTO) and final magnitudes computed using as reference the UCAC4 i magnitudes. The typical photometric accuracy was 0.15 mag.

The color correction, due to the different passbands of the Sloan i filter and the filter/emulsion combination of the plates, was found always to be small, of the order of 0.1 mag.

For each star the average magnitude and rms deviation was computed using all the available plates: variable stars are expected to show an rms value much larger than the constant ones.

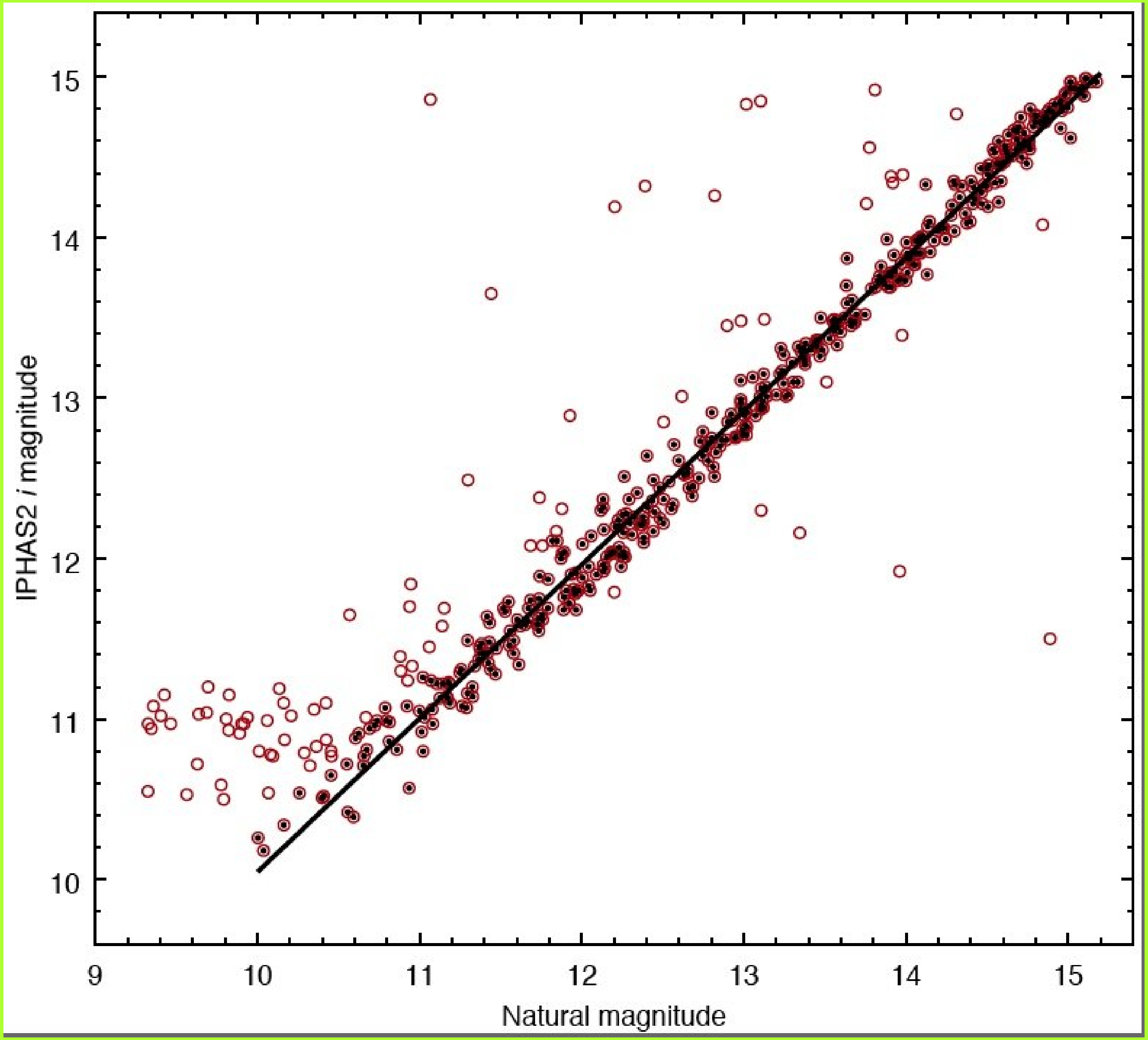
A first list of probable variables was selected in this way for eye inspection of their light curve and spectroscopic follow-up.

Sample image



A section 601x601 pixels of the plate S90/00801, showing the variable V890 Cas at maximum

Photometric test



Comparison of our computed magnitudes for the 530 candidates with the IPHAS2 catalog ones.
Saturation of the IPHAS2 catalog around mag=11 is apparent.
Variable stars are generally out of the fit line because observed at different phases of their light curve.

Variables found

Only 21 stars showed to be significantly variable:
10 stars are regular Miras;
5 stars show long term trends;
3 stars look SR;
3 stars Irregular.

Of these 21 stars:
10 were already present in the GCVS or VSX;
5 have a clear counterpart in NSVS database;
6 were new discoveries: one of them is a Mira, 2 have long term trends, 3 are Irregulars.

Only 4 Miras had a published period, and we improved the accuracy of their periods given our long time baseline. For the remaining 6 we determined the period for the first time.

All the known red variables in the field were recovered.

Spectral types

Spectral types of the 21 variable stars were derived from CCD slit spectra taken at Loiano and Asiago Observatories:

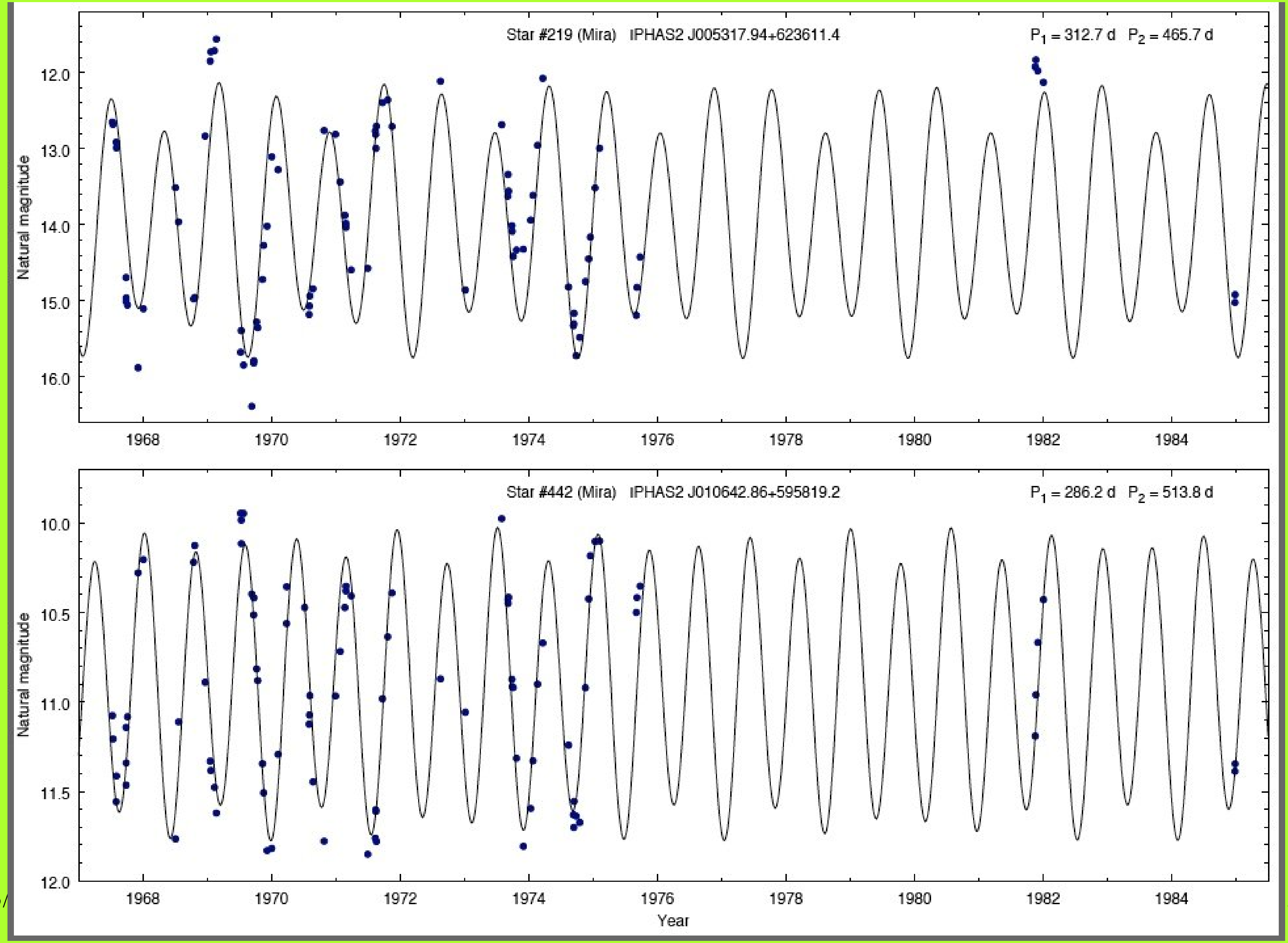
8 stars of M-type;
7 stars of C-type;
6 stars of S-type.

10 stars had no previous spectral classification in the literature. For the remaining 11, we found a fair agreement with our classification.

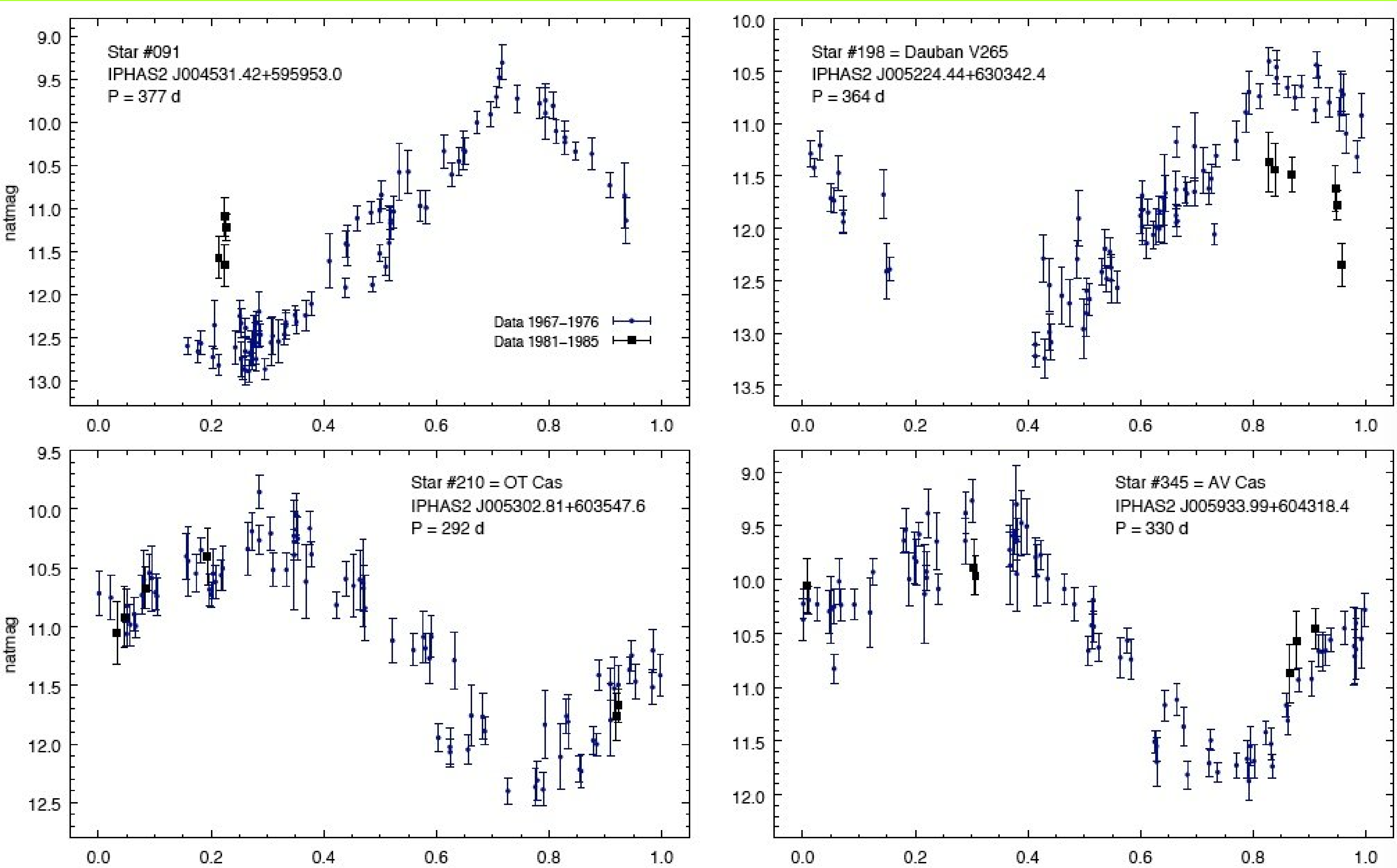
The fraction of S-type stars in our sample is rather high.

All the Carbon stars, and only them, have long term trends in their lightcurve, none of them being a regular Mira.

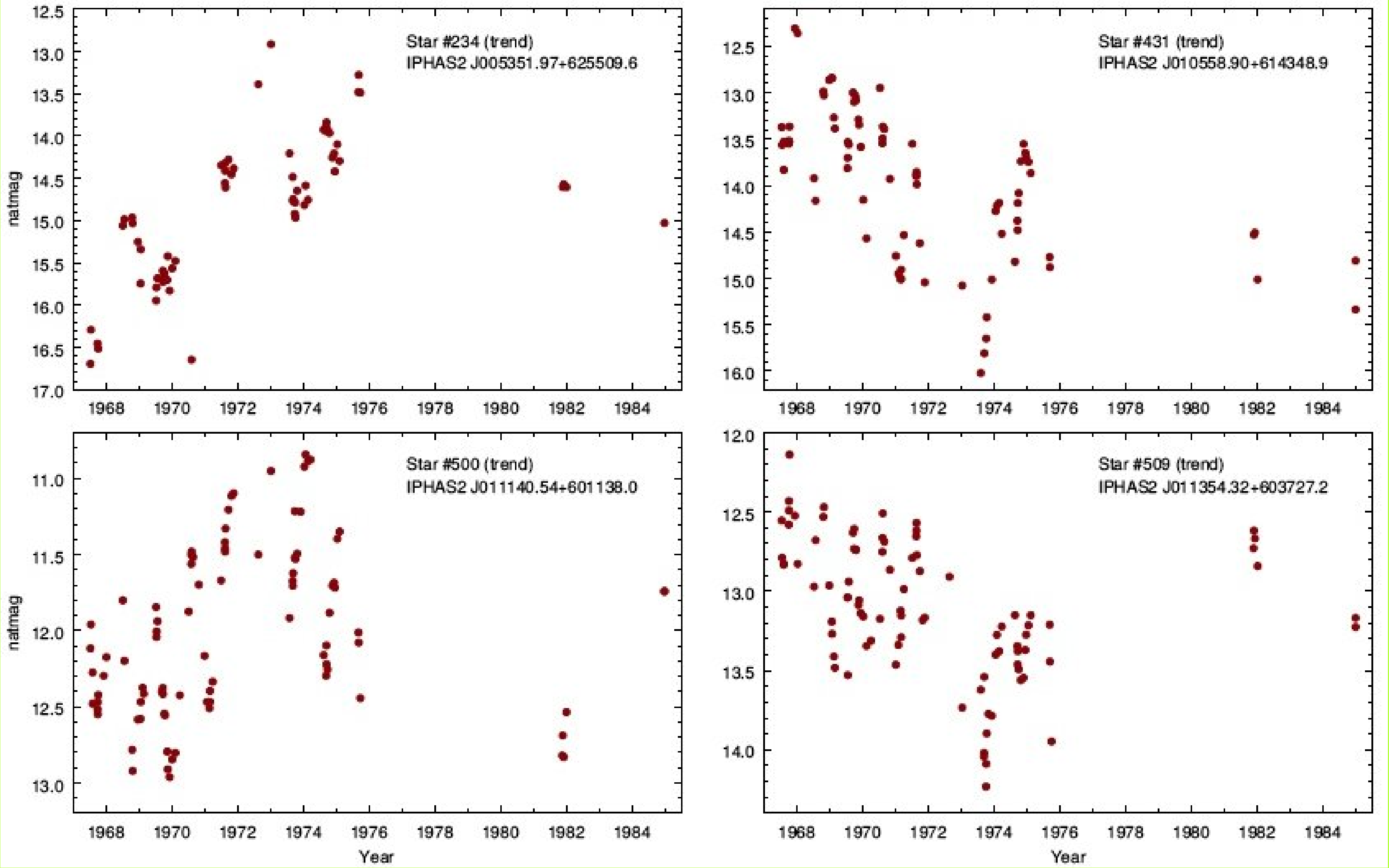
Double period Miras



Some phased light curves



Long trend light curves



Mira distances

Distances of the Miras were estimated computing their absolute magnitude from the period-magnitude relation by Whitelock et al. (2012).
From the apparent K magnitudes the distance determination is easy, given the low absorption in this band.

A large spread among the distances of these stars was found, with median value 4.9 kpc.
This is larger than expected if the stars belonged to the Perseus Arm, which is located at about 2.4 kpc from the Sun in Cassiopeia.

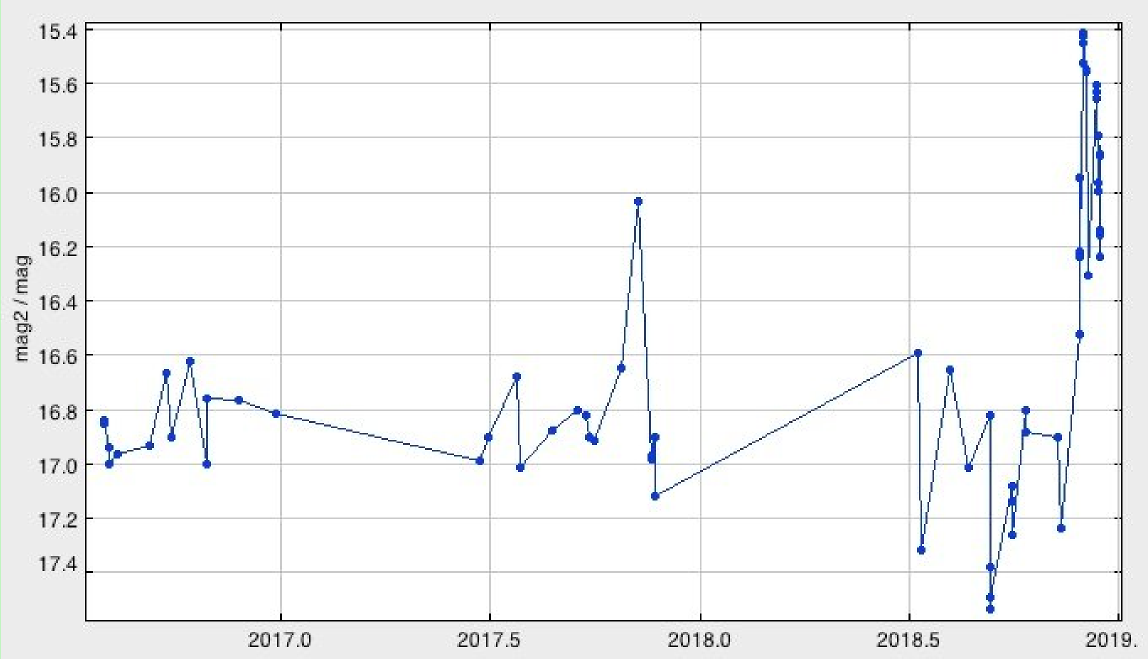
The distance measurements from the Gaia DR2 catalog are in rather poor agreement with those derived from their absolute magnitudes. However, for the majority of our stars the Gaia estimates have very poor statistical quality factors, likely due to their large variability.

Color-color plots were derived from IPHAS2 and 2MASS catalog data:
S-type and M-type stars occupy the same regions in these plots, so cannot be distingushed from photometric data alone, while Carbon stars are well separated.

Cataclismic variable

The second case is that of the star ASASSN-18aan, discovered last November.
This is a rather blue object, present in the same plates of Gamma Cas described above.
We looked for this star both in the I-N and the 103aO plates.
The star was always detected in the blue plates, generally near the plate limits.
It was generally not detected in the I-N plates, save in few ones.
This is not strange given the different limiting magnitude of the two emulsions and the color of the star.

Light curve, with only actual detections in the ASASSN database, showing the flare in Nov 2018.
The star was never detected by ASASSN in the preceding years.



Data reduction

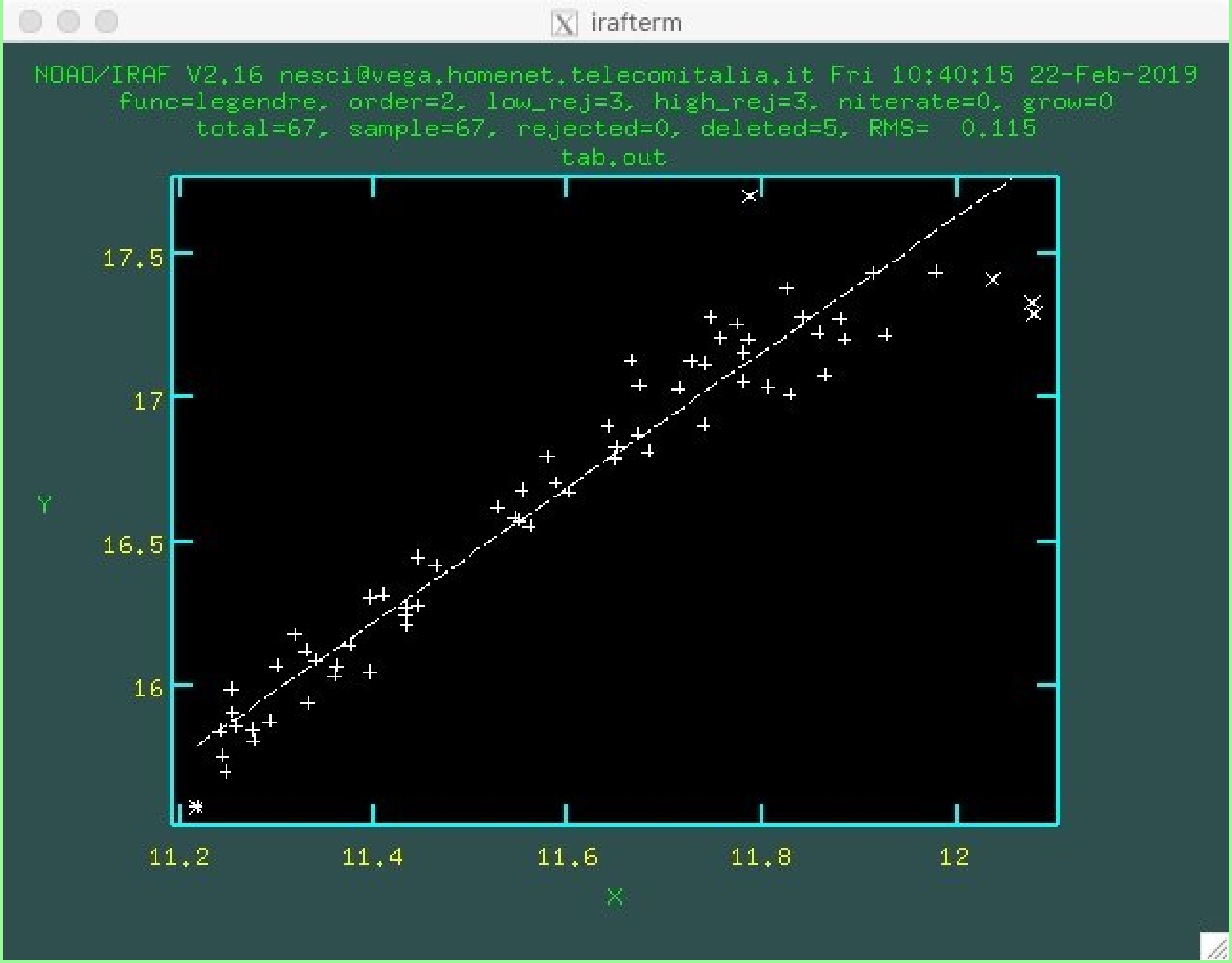
Eye inspection of the digitized plates allowed to identify the star in each plate.
A section of 300x300 pixels centered on the star was then extracted for analysis: the images were converted from transparency to intensity simply inverting the data number I=65563-T.

Aperture photometry was made with IRAF/apphot using a set of comparison stars taken from the Panstarrs DR1 with g filter magnitudes.
A linear fit of the instrumental vs catalog magnitudes was obtained, in the magnitude range 15.5 - 17.5, with typical rms deviations of 0.15 mag.

The star was generally found faint, around g=17.5; but in 4 plates it was rather bright, g~16.

Linear calibration fit

A typical photometric fit for a blue plate: instrumental magnitudes in abscissa, catalog magnitudes in ordinate.
Most deviant stars are manually excluded from the fit (crosses).



Detected outbursts

We catched three clear outbursts in the 103aO blue plates, confirmed by the I-N plates.

Blue plate	MJD	g	err	i	err
1898	40152.82	16.0	+-0.16	15.7	+-0.2
2544	40486.11	15.8	+-0.16	15.4	+-0.2
2548	40487.08	15.8	+-0.17		
3590	40822.91	15.6	+-0.15	15.4	+-0.2

Given the loose time sampling, about one every two or three weeks, the plates preceding and following the outburst were generally rather far in time and showed the star at the quiescent level.
The outbursts duration therefore cannot be determined with this dataset.
From the ASASSN light curve it is of the order of 2 weeks, so it is not strange that the outbursts are generally detected only in one plate in the Asiago archive.

Recurrent source?

A recurrence of about 11 months for the outbursts can be inferred from the Asiago data.

An outbursts ephemeris for the years covered by the Asiago plates was then computed.

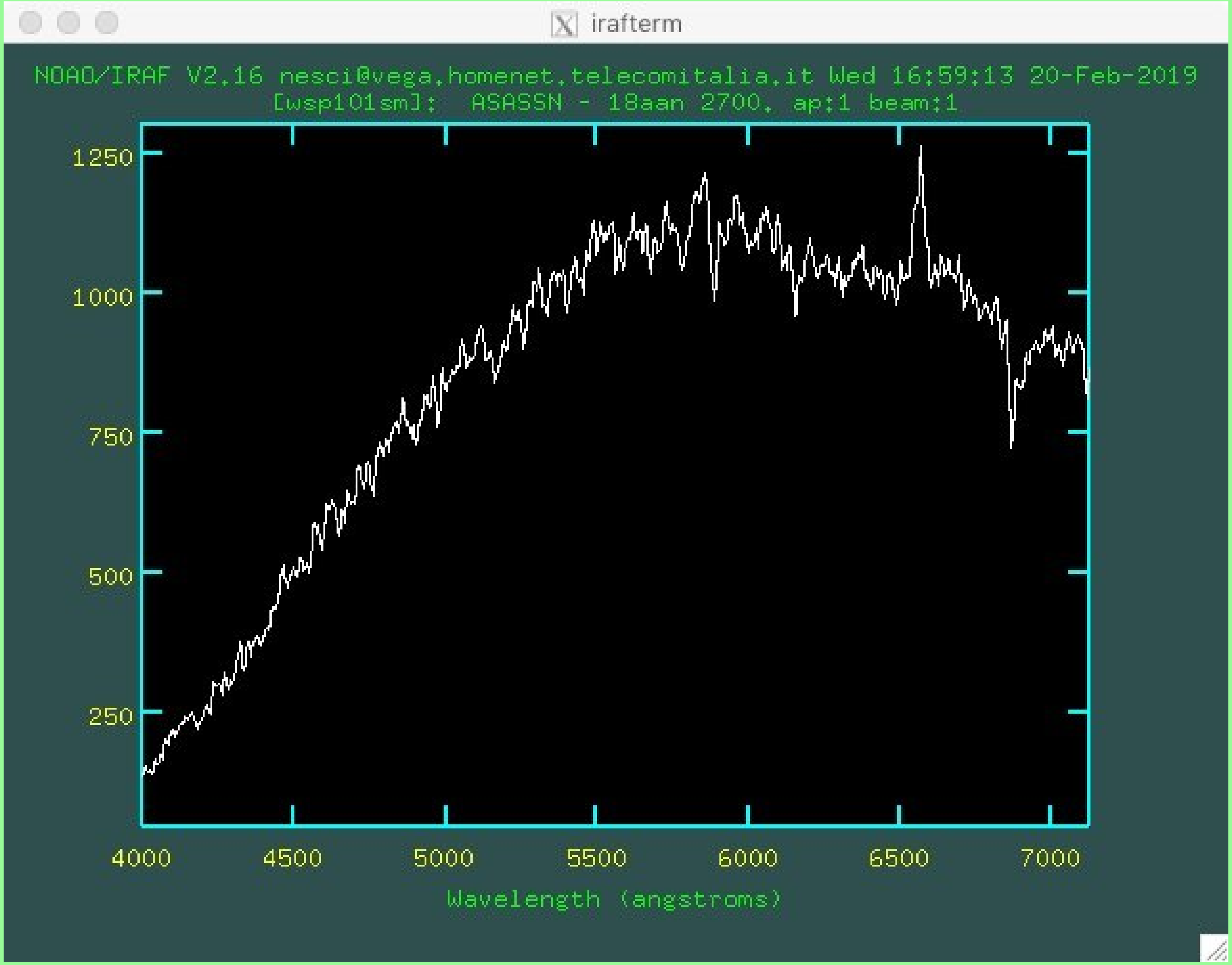
Unfortunately no plates were available for the epochs near to the predicted outbursts, so it is not possible to confirm or exclude this possibility.

The ASASSN outburst happened at the end of November 2018. The previous outbursts (if any) should be happened in the seasonal gaps of the ASASSN database, so cannot be checked.

If there is an 11 month recurrence, the next episode should happen in September-October 2019, when the star will be easily observable.

Spectroscopic follow-up

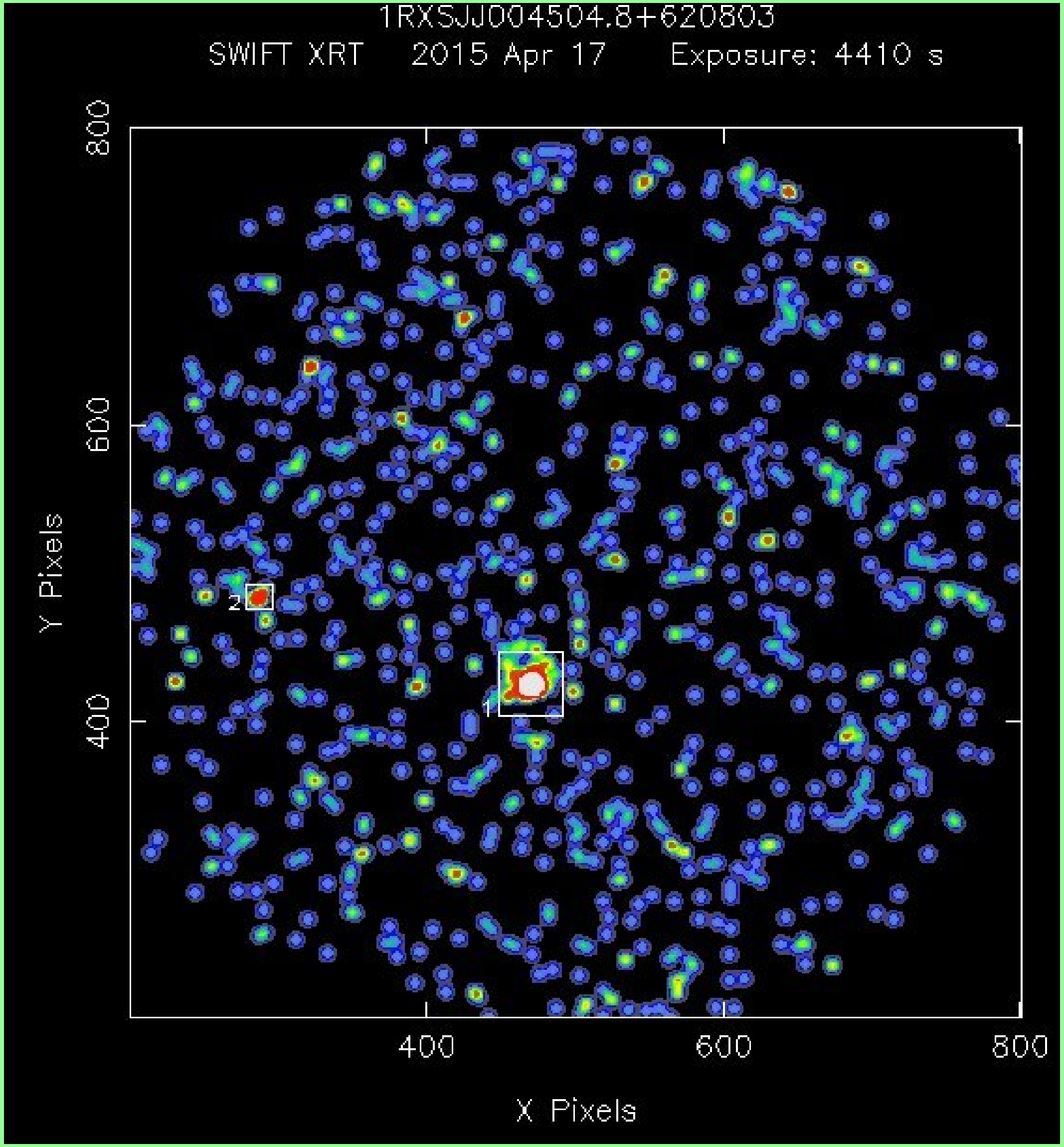
A spectrum of the star at the quiescent level was secured with the Loiano 1.5m telecope on February 5 2019, showing H-alpha and [NII] emission, as expected for a cataclismic binary.
From the absorption lines, I derived a spectral classification of G-K type, consistent with the Gaia and PanSTARRS colors.



Swift X-ray data

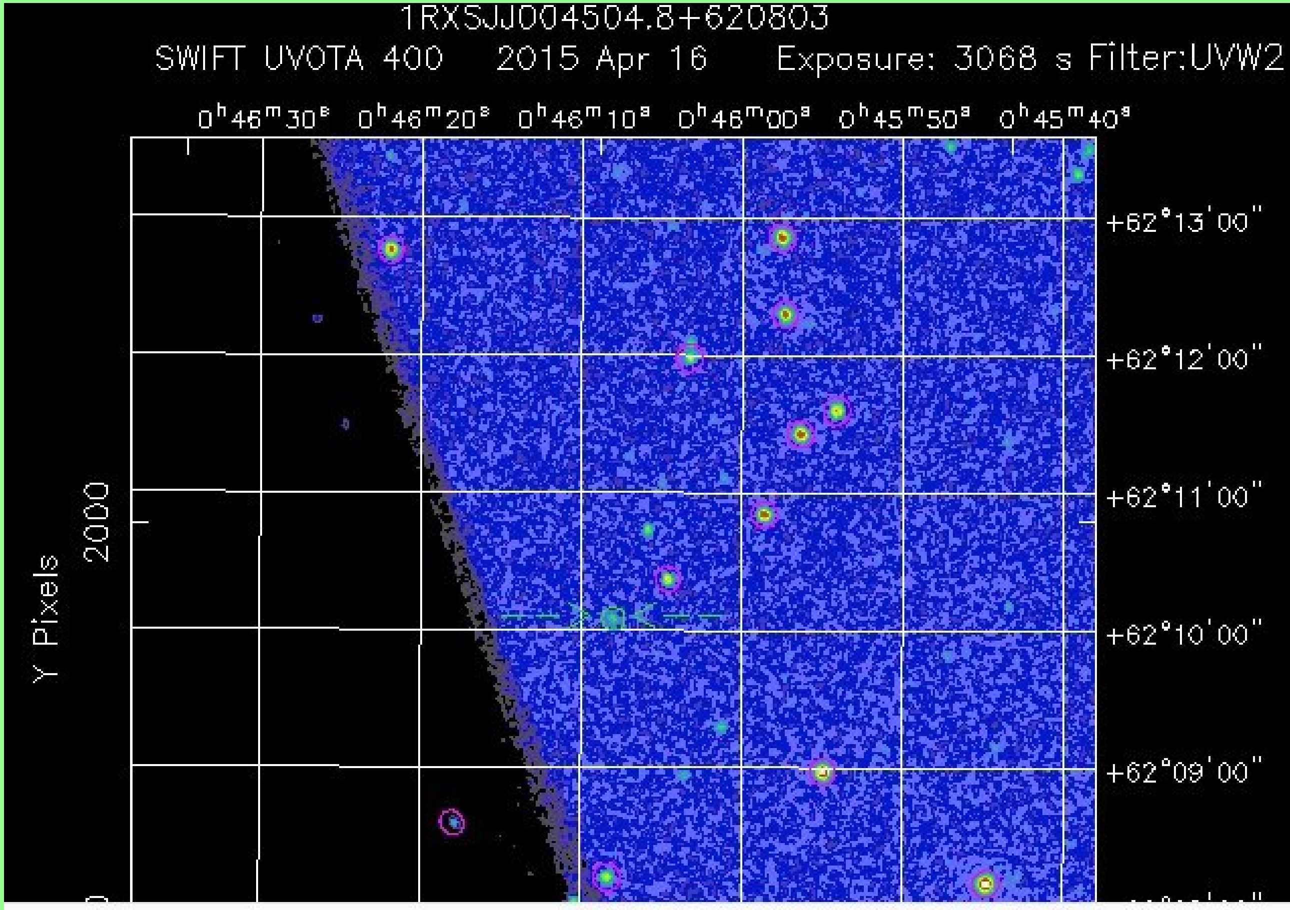
In the Swift archive there are several XRT and UVOT images containing this star. They were taken as follow-up of a nearby INTEGRAL and ROSAT AGN candidate, unrelated to our object. The AGN is source #1, our star is source #2.

The star was always detected in X-ray, but at a very low count rate (0.005 c/s), so that no spectral information can be derived.



Swift UVOT data

- The star was also always visible in the W2 filter of UVOT, the only one used in these pointings, at a magnitude 20.7.
  A strong absorption is expected at this wavelength (2000 A), about 8 or 9 magnitudes, even if the star is not very far (700 pc according to the Gaia parallax), so it is not straightforward to derive physical parameters for the compact companion/accretion disk.



The ultraviolet and X-ray data confirm the nature of X-ray binary for the star.

Conclusions

The plate archives contain a great quantity of informations than can complement in a very useful way modern observations from the space and from the ground.

The ever increasing amount of data collected by the robotic telescopes may help to add new value to these archives.