

Search for Nova Super-remnants

Campaign Conducted by Amateur Telescopes in Automated Operation

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Abstract

In recent years, aesthetic astrophotography and scientific exploration of the universe have increasingly converged. By combining numerous wide-field images taken with narrowband filters into extremely long total exposures, it has become possible to reveal previously unseen extended structures in the night sky with very low surface brightness. These include faint nebulae, stellar streams around galaxies, supernova remnants, and similar objects. Diffuse shells created by repeated nova explosions represent another promising area of study. Unlike the expanding shell produced by a single, recent nova event, a nova super-remnant is the cumulative result of multiple eruptions over time.

Gas from successive explosions interacts and heats the surrounding low-density medium, producing faint emission spectra with a peak at the $H\alpha$ wavelength of 656.3 nm. The first successful detections have already been reported. Research has naturally begun with recurrent novae, which erupt most frequently. Notable examples include the recurrent nova M31N 2008-12a in the Andromeda Galaxy [1] and KT Eri [2], which was previously only suspected of being recurrent. The Condor Telescope Array in New Mexico [3], specifically designed for detecting low surface brightness objects, plays a key role in this effort.

However, comparable results can also be achieved with the equipment of advanced amateur astrophotographers. To accumulate sufficient total exposure time, the coordinated effort of multiple telescopes operating in an automated regime is essential. At present, nine Slovak and Czech astrophotographers are participating in this campaign. We have already completed a pilot project targeting the known nebula around cataclysmic variable Z Cam, serving as a test of our capabilities. In the summer of 2025, several additional candidate objects were observed with relatively short total exposure times. The next step is to select the most promising targets for deep, long-term imaging.

The main challenge for our campaign is the limited observing time caused by adverse weather in Central Europe. One of our telescopes is already operated remotely from a hosting site in Spain, and we plan to establish our own telescope-hosting facility in southern Spain to ensure more consistent observing conditions.

Introduction

Probably each CVs undergo nova eruption many times. Frequency $\propto M_{WD}$.

- $M_{WD} \sim 1.4M_{\odot}$ - 1 year cycle (M31N 2008-12a)
- low-mass WDs - $> 1Myr$
- $M_{WD} > 1.2M_{\odot}$ - recurrent nova

Definition of recurrent nova: More than one eruption in a century. So far, only 11 known Galactic recurrent novae. However, according to [4] calculation - 25% of novae are RN.

Simulations of the shell formation

Large impact on nova super-remnant (NSR) growth has interstellar medium (ISM) density and white dwarf temperature.

Increase in local ISM density results in a smaller NSR.

Lower accretion rate leads to more extended, but less well-defined NSR.

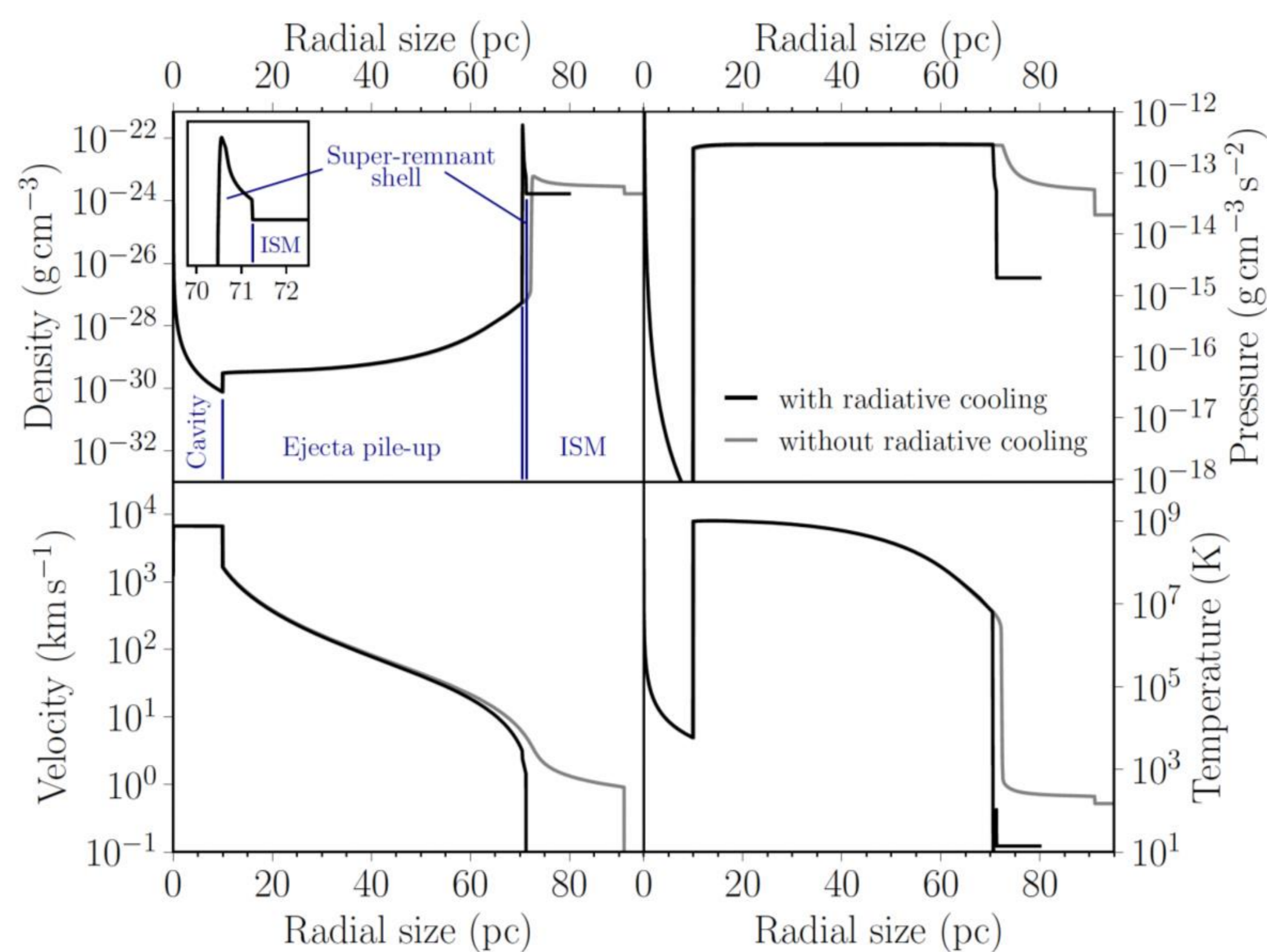


Figure 1: Simulations of nova super-remnant grow. Source: [2]

Nova Super-Remnant discovered up to now

	M31N 2008-12a	KT Eri	T CrB	RS Oph
Distance [pc]	7.5×10^5	5110	914	2680
Angular size [']	0.6×0.4	36	120	90
Physical size [pc]	134×90	50	32	70
Surface brightness [$erg s^{-1} cm^{-2} arcsec^{-2}$]		4×10^{-17}	6.6×10^{-18}	1.4×10^{-17}
WD mass [M_{\odot}]	1.38	1.23	1.37	1.35
dM/dt [$M_{\odot} yr^{-1}$]	$\sim 10^{-6}$	3.5×10^{-7}	3×10^{-8}	1.2×10^{-7}
Recurrence [year]	1	~ 50	80	15
NSR age [year]	6×10^6	5×10^4	$\sim 2 \times 10^5$	$5 - 10 \times 10^4$
NSR mass [M_{\odot}]	10^{5-6}		< 300	20 - 200

Table 1: Basic parameters of known nova super-remnants

Our campaign

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#	Optics	CMOS camera	FoV[arcmin]	Observer	Site
1	Newton 300/1200	MII C3-61000	103×68.8	K. Kolomazník	Kolonica
2	Newton 406/1800	MII C4-16000	70.4×70.4	P. Dubovský, R. Adam	Kolonica
3	Refracting 100/412	QHY268M	196×129	R. Barsa	Kolonica
4	Newton 350/1400	Atik APX60 Mono	88×59	D. Volný	Stupava
5	Refracting 102/560	SV605MC	67.8×67.8	M. Mančúška	Boldog
6	Newton 250/1000	ZWO ASI1600MM	61×46	M. Gnida	V. Chlievany
7	Refracting 130/910	ZWO ASI 6200MM	136×91	A. Kováč	Trevinca
8	Newton 250/950	ZWO ASI 2600MM	85×57	P. Jurista	Martin
9	Newton 500/2000	FLI PL16803	36.8×36.8	P. Kollárik	Šenkvice

Table 2: Telescopes involved in the campaign



Figure 2: 3 of 9 telescopes are operated in the new pavilion at the Astronomical Observatory in Kolonica Saddle, eastern Slovakia.



Figure 3: Result of the pilot campaign on the nova shell of Z Cam. Red color corresponds to $H\alpha$ emission, blue comes from [OIII] band.

Results

For the pilot campaign, we selected the field around Z Cam with the aim of assessing whether it is possible to construct an image of a faint, extended object by combining data from different instruments. A total exposure time of 378 hours was acquired. The majority of the observations were carried out using the $H\alpha$ filter, with the remainder obtained in [OIII] and [SII].

Target	Dec	b	dist. [pc]	P_{orb} [d]
V838 Her	+12	+6	3128	0.29764
V825 Her	+41	+34	1048	0.206
V380 Oph	+06	+16	686	0.15348
V363 Aur	+36	+2	816	0.32124
ZTF18abaebjo	+68	+22	2878	0.206
SDSS J195939.71	+65	+18	3774	0.3263
+655440.9				

Table 3: The list of targets selected for deep imaging.

How to recognize Nova Super-remnant

Shock excitation at low velocities $V < 80$ km/s
 $[SII]/H\alpha \geq 0.5$
 No [OIII]; No continuum

Lower surface brightness than HII region:
 HII: $\sim 10^{-15} erg s^{-1} cm^{-2} arcsec^{-2}$
 NSR: $\sim 10^{-17} erg s^{-1} cm^{-2} arcsec^{-2}$

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