Identifying Recurrent Novae in the Set of Classical Novae

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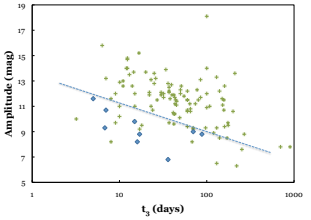
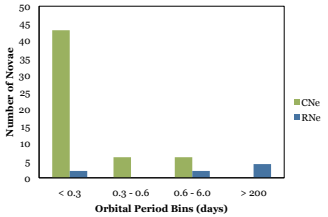
Some fraction of the systems currently labeled as classical novae (CNe) must actually be recurrent novae (RNe), with multiple thermonuclear nova eruptions within the last century, of which only one has been observed. We report on a detailed study of 236 cataloged CNe aimed at identifying those which have properties indicating a recurrence timescale of less than a century or so. We introduce two new criteria that point to short recurrence times: high expansion velocities during outburst, as measured by the full-width half-max of the Hα line, and the presence of high excitation lines such as He II and [Fe X] in the outburst spectra. All of the known recurrent novae have expansion velocities greater than 2000 km/s and He II lines, and most have iron lines at or above [Fe X], while only a fraction of the CNe display these properties. Additionally, we use previously-published criteria (e.g. location on Duerbeck's amplitude/t_3 plot, indication of a red giant companion, and outburst light curve shape, such as the plateaus noted by Hachisu & Kato) to identify good RN candidates. Roughly 85 of the CNe have properties that point to a fast recurrence timescale, and 15 of these have multiple properties indicating they are strong RN candidates.

Classical Novae

GCVS Name	Type	Amp. (mag)		P_{orb} (days)		t_3 (days)		FWHM Hα (km/s)		He II ?		Fe ??		Other Lines		J - H		H - K		Other	
AT Cru	n:/dq	11	1	0.213	1																
AT Sgr	nr:	8	1			-	37			-	37	-	37								
BC Cas	nr:	6.7	1																		
BS Sgr	nb	7.8	1			700	2			-	37	-	37			0.61	S	0.1	S		
BT Mon	na	7.6	1	0.334	1	253	3	2100	69	Yes	69					0.43	S	0.16	S		
BY Cir	n	10.7	1	0.282	1	157	44, 51														
CK Vul	nb	18.1	1			100	2			-	37	-	37			0.28	6	1.04	6		
CN Vel	nb	7.6	1							-	37	-	37								
CP Cru	nr:	10.2	1	0.944	1	10	47	2000	52	Yes	52										
CP Lac	na	14	1			12	3			No	37	Fe II	37								
CP Pup	na	14.7	1	0.061	1	12	3			Yes	37	[Fe X]	37			0.39	S	0.01	S		
CQ Vel	nr:	12	1			50	2			-	37	-	37								
CT Ser	n	8.7	1	0.191	1	-	37			No	37	[Fe X]	37			-0.06	S	0.91	S		
DD Cir	na/dq	12.7	1	0.097	1																
DE Cir	n							5100	12												
DI Lac	na	10.4	1	0.544	1	43	2			No	37	Fe II	37			0.18	7	0.175	7		
DK Lac	na	10.5	1			41	3			No	37	Fe II	72			0.443	7	-	7		
DM Gem	na	11.9	1			22	2			No	37	-	37								
DN Gem	na	12.5	1	0.128	1	37	2			No	37	[Fe X]	37			0.231	7	-0.077	7		
DQ Aql	nb	7.8	1	0.168	1	900	2			No	37	[Fe XI]	37			-	S	-	S		
DQ Her	na/dq	13.3	1	0.194	1	130	3			No	37	Fe II	37			0.274	7	0.194	7		
DY Pup	nb	12.6	1	0.139	1	160	2			-	37	-	37								
DZ Ser	n	7	1																		
EL Aql	na	13.6	1			25	2			-	37	-	37			0.95	S	0.17	S		
EU Sct	na	9.6	1			62	2			No	37	Fe II	37			0.93	50	0.5	50		
EY Aql	nr:	9.5	1			-	37			-	37	-	37								
FH Ser	na	13.1	1			85	3			-	37	-	37			0	S	0.79	S		
FL Sgr	nr:	11.7	1			32	2			-	37	-	37								
FM Sgr	nr:	11.9	1			30	2			-	37	-	37								
FS Sct	nr:	9.2	1							No	37	Fe II	37								
FV Sct	n	7.5	1																		
GI Mon	na/dq	11	1	0.180	1	23	2			No	37	-	37			0.311	7	0.22	7		
GK Per	na/dq	13.7	1	1.997	1	15	3			No	37	Fe II	37	Ne V	37						
GQ Mus	na/sm	11.1	1	0.059	1	45	2														
GR Sgr	n	5.2	1			37	2			-	37	-	37			0.35	7	-0.14	7		
HR Del	nb	8.8	1	0.214	1	269	3									0.07	S	0.07	S		
HR Lyr	na	9.3	1			97	22			-	37	Fe II	37								$Amp./t_3$ 22
HS Pup	nc	10.8	1			65	2									0.462	7	0.52	7		
HS Sge	na	13.7	1			20	2														
HS Sgr	nb	5	1			-	37			-	37	-	37								
HY Lup	n	10.9	1																		
HZ Pup	na	9.3	1	0.213	1	70	2									0.243	7	0.087	7		
IL Nor	nb	11	1			108	2			-	37	-	37								
IV Cep	na	9.7	1			37	2														
KP Sco	nr:	11.6	1			38	2			-	37	-	37								
KT Mon	na/we					40	2			Yes	41	Fe II	37	NIII	4						
KY Sgr	nr:	9.4	1			60	2			-	37	-	37								
LS And	nc:	8.8	1																		$Amp./t_3$ 8
LV Vul	na					21	2														
LV Vul	na	11.4	1			41	3									0.44	S	0.27	S		
LW Ser	na	12.3	1			59	2									-	S	-	S		
LZ Mus	na																				
MQ Ser	na					5	2														
NQ Vul	na	12.3	1			77	3									0.1	S	2.03	S		
OS And	n	12.1	1			37	2														
OY Ara	na	11.5	1	0.155	1	80	2			-	37	-	37								
PW Vul	na	11.5	1			157	3									-	S	-	S		
Q Cyg	na	12.6	1	0.420	1	11	2			Yes	37	Fe II	37			0.319	7	0.149	7		
QU Vul	na	11.9	1	0.312	1	40	2														
QV Vul	na	10.7	1			60	2														
QZ Aur	na	11.5	1	0.357	1	27	2									0.556	7	0.249	7	Mass	10
RR Cha	na/dq	12.2	1	0.140	1	60	2														
RR Pic	nb	11.1	1	0.145	1	152	3			No	37	Fe II	37			0.22	S	0.06	S		
RS Car	n	11	1							-	37	-	37								
T Aur	nb	11	1	0.204	1	85	37			No	37	Fe II	37			0.3	57	0.141	7		
V Per	n	9.3	1	0.107	1					-	37	-	37								
V351 Oph	n	8.2	1																		
V352 Sgr	nr:	12	1			32	2			-	37	-	37								
V354 Sgr	nr:	9.1	1																		
V355 Sgr	nr:	13.9	1			34	2			-	37	-	37								
V356 Sgr	na	8.5	1			140	2			-	37	-	37								
V357 Sgr	nb/sb:	6.5	1	1.780	1	130	2			-	37	-	37			0.58	56	0.17	56		
V1039 Cen	na			0.247	1																
V1047 Cen	n							840	28												
V1059 Sgr	na	13.2	1													0.27	S	0.07	S		
V1141 Sco	n	9.1	1																		
V1142 Sco	na							3800	13												
V1148 Sgr	n						37			-	37	-	37								
V1149 Sgr	nb	13.6	1			210	2			-	37	-	37								
V1150 Sgr	nb					-	37			-	37	-	37								
V1151 Sgr	nb	8.9	1			-	37			-	37	-	37			-	7	-	7		
V1172 Sgr	n	9	1													1.14	7	0.396	7		
V1174 Sgr	n					-	37			-	37	-	37								
V1175 Sgr	n																				
V1178 Sco	na																				
V1186 Sco	nb							500	24												
V1187 Sco	n																				
V1188 Sco	n							1730	34												
V1209 Aql	na	12.7	1			39	3														
V1275 Sgr	na	11	1			30	2			-	37	-	37			0.582	7	0.154	7		
V1301 Aql	na	10.7	1																		
V1310 Sgr	nb:																				
V1330 Cyg	na	9.5	1			38	2									-	7	-	7		
V1370 Aql	n	13.5	1			11	2									0.45	S	0.6	S		
V1378 Aql	n	11	1			15	2														
V1419 Aql	na					32	2														
V1435 Aql	na/dq			0.256	1																
V1493 Aql	na			0.156	1																
V1494 Aql	n			0.135	1			2000	14												
V1500 Cyg	na/sm	15.8	1	0.140	1	6	3														Mass 11
V1548 Aql	n																				
V1572 Sgr	n																				
V1583 Sgr	nr:	12.1	1			37	2														
V1668 Cyg	na	13.1	1	0.138	1	23	2														
V1819 Cyg	nb	10.9	1			100	2	2742	15												
V1944 Sgr	n																				
V1974 Cyg	na	11.9	1	0.081	1	42	2														
V2524 Oph	n																				
V2competitor Oph	n	11.7	1																		
V2109 Oph	n	7.2	1																		
V2214 Oph	nb/sm	12	1	0.118	1	100	2														
V2competitor Oph	na																				
V2274 Cyg	na							950	30												
V2275 Cyg	na	11.7	1	0.315	1			3199	14												
V2competitor Oph	na					50	2														
V2competitor Oph	na																				
V2competitor Cyg	na																				
V2competitor Cyg	n							1800	34												





Summary of Criteria

Criterion	% of RNe⁺	% of CNe⁺	Physical Justification
Orbital Period > 0.3 days	78	24	Indicates evolved donor star, the expansion of which drives high accretion rate
Location on Duerbeck Amplitude/t_3 plot	100	11	RNe brighter in quiescence, but all novae have same peak mag, so RN amplitude is lower
			High expansion velocities and low envelope mass lead to short t_3
FWHM of Hα > 2000 km/s	100	45	HIgh-mass WD → High Escape Velocity → High Expansion Velocity
He II, Fe X (or higher), Other High Lines	100	14	High-mass WD → High Surface Gravity → Energetic Explosion
Infrared Excess	40	16	Indicates evolved donor star, the expansion of which drives high accretion rate
Other (Mass of WD, Plateaus in LC, etc.)	-	-	Various

⁺Percentages are based on the number of systems for which there is data about that characteristic

Recurrent Nova Candidates

Name	P_{orb} (days)	Amp./t_3	FWHM Hα	He II	Fe ??	Other Lines	IR	Other	Total
V2487 Oph	-	Yes	10000	Yes	-	-		Mass, t_3, pl	5
V838 Her	0.30	Yes	5000	Yes		Ne V		Mass	5
BT Mon	0.33	Yes	2100	Yes					4
CP Cru	0.94	Yes	2000	Yes					4
V368 Aql	0.35			Yes	Fe X				3
DN Gem	0.13			No	Fe X		Yes		2
GK Per	2.00			No	Fe II	Ne V			2
KT Mon				Yes		NIII			2
Q Cyg	0.42			Yes	Fe II				2
QZ Aur	0.36							Mass	2
V1017 Sgr	5.78	Yes		-	-				2
V1172 Sgr			5000				Yes		2
V2275 Cyg	0.31		3199						2
V723 Cas	0.69				Fe XVII				2
V723 Sco		Yes					Yes		2

Recurrent Novae

GCVS Name	Type	Amp. (mag)		P_{orb} (days)		t_3 (days)		FWHM Hα (km/s)		He II ?		Fe ??		Other Lines	
CI Aql	nr	6.8	1	0.618	1	36	14	2250	36	Yes	36	[Fe VII]	68		
RS Oph	nra	8.2	1	455.720	1	16	2	3930	39	Yes	70	[Fe X], [XI], [XIV]	64	Ni XV	64
T CrB	nra	9.3	1	227.569	1	7	2	4980	40	Yes	40	[Fe X], [XIV]	40	Ni XVI	40
V3890 Sgr	nra	8.8	1	519.700	63	17	21	2140	35	Yes	38	[Fe X]	38		
V745 Sco	nra	9.8	1	510.000	63	15	21	3600	38	Yes	69	[Fe X], [XI]	66		
IM Nor	nrb	9.3	20	0.103	1	70	20	2380	65	Yes	65	[Fe X]	65		
T Pyx	nrb	8.8	1	0.076	1	88	2	5350	67	Yes	67	Fe II	67		
U Sco	nrb	10.7	1	1.231	1	5	20	5700	42	Yes	42	Fe III	71		
V394 CrA	nrb	11.6	1	1.516	63	5	21	4600	41	Yes	38, 41	-			

Classical Novae

GCVS Name	Type	Amp. (mag)		P_{orb} (days)		t_3 (days)		FWHM Hα (km/s)		He II ?		Fe ??		Other Lines		J - H		H - K		Other	
V2615 Sgr	n																				
V2487 Oph	nr	8.2	1	-		8	62	10000	43, 44	Yes	43	-		-						Amp./t_3 11	
V2491 Cyg	n							4800	75											Mass 75	
V5140 Oph	nb			0.285	1																
V2572 Sgr	nr:	11.5	1			44	2														
V5176 Oph	n							2285	18												
V916 Pup	n/nb	13.2	1	0.118	1	26	2														
V356 Aql	nb	10.6	1			200	2					No	37	Fe II	37			0.85	S	-0.77	S
V361 Sgr	nb	11.2	1			64	2					-	37	-	37						
V3645 Sgr	nb	5.4	1															0.8	50	0.69	50
V401 Cyr	nb	8.4	1																		
V366 Scl	n																				
V368 Aql	na	10.4	1	0.345	1	62	2	-	37	Yes	37	Fe II	37								
V368 Scl	na	12.1	1			30	2														
V373 Scl	na/dq	11.7	1			85	2														
V378 Ser	n																				
V382 Nor	n																				
V382 Vel	na	13.9	1	0.158	1																
V388 Sgr	nb	12	1			7.8	2														
V389 Sgr	nr:	12.6	1			14	2														
V4964 Sgr	na					32	2											0.343	7	-	7
V490 Per	na	11.7	1			43	2														
V4021 Sgr	na	9.2	1			70	2														
V4027 Sgr	n																				
V4068 Sgr	n	9	1																		
V4074 Sgr	nb/z sn																	0.79	S6	0.28	S6
V4077 Sgr	nb	14	1			100	2														
V4121 Sgr	n	11.5	1			60	2														
V4115 Sgr	n	11.5	1			60	2														
V4157 Sgr	na																				
V4160 Sgr	na																				
V4169 Sgr	na					70	2														
V4171 Sgr	na	12.5	1																		
V4327 Sgr	na																				
V4361 Sgr	n	6.3	1																		
V4362 Sgr	nb																	0.426	7	1.005	7
V441 Sgr	na					53	2					-	37	-	37						
V448 Sct	n					80	2														
V448 Sct	na	9.5	1																		
V4444 Sgr	na/nr							800	27											Dust	9
V645 Pup	nc:																				
V646 Her	na	14.8	1	0.207	1	12	3	1188	23									0.107	7	0.618	7
V650 Cyg	nb	8.5	1			171	3					No	37	Fe II	37			0.38	S	0.42	S
V679 Sgr	nb	5.5	1																		
V682 Scl	na							940	29												
V4633 Sgr	na			0.126	1													-0.017	7	0.706	7
V4642 Sgr	na																				
V4643 Sgr	na	7.9	1																		
V445 Cyg	nb	12.2	1			140	2					No	37	Fe II	37						
V4739 Sgr	na							5510	19												
V4740 Sgr	na																				
V4741 Sgr	na																				
V4742 Sgr	na																				
V4743 Sgr	na	11.8	1	0.281	1																
V4744 Sgr	na																				
V4745 Sgr	n																				
V476 Cyg	na	15.2	1			17	3					No	37	Fe II	37						
V476 Scl	n																				
V477 Sct	n																				
V500 Aql	na	11.2	1	0.145	1	43	3														
V513 Sgr	n							550	25												
V514 Sgr	n							1300	32												
V515 Sgr	n							1300	33												
V516 Sgr	n							970	28												
V528 Aql	na	12.2	1			37	2					No	37	Fe II	37						
V533 Her	na	11.8	1	0.147	1	55	3	1188	23									0.032	7	0.035	7
V551 Oph	na	9.5	1																		
V578 Pup	n							650	26												
V603 Aql	na/dq:	12.9	1	0.139	1	10	3					No	37	Fe II	37			0.25	S	0.16	S
V606 Aql	na	12.8	1			25	2					-	37	-	37						
V606 Aql	na	10.6	1			65	2					Yes	37	-	37						
V630 Sgr	na	13	1	0.118	1	51	2					No	37	-	37	Ne V					
V655 CrA	n	9.6	1																		
V693 CrA	na	14	1			12	2														
V696 Sco	na	12	1			9	2					-	37	-	37			0.191	7	0.082	7
V697 Sco	na/dq	9.8	1	0.187	1	15	2					-	37	-	37						
V705 Cen	na	11.6	1																		
V707 Sco	na	10.1	1			69	2														
V718 Sco	na	10.7	1			24	2														
V720 Sco	n	13.5	1									No	37	Fe II	37						
V721 Sco	n											-	37	-	37						
V722 Sco	na					18	2					-	37	-	37						
V723 Cen	nb			0.693	1	189	53					[Fe XVI]	53								
V723 Sco	na/nrs	9.2	1			17	2											1.09	S	0.37	S
V726 Sgr	na	8.2	1			90	73														
V729 Sco	n or m	8	1																		
V732 Sgr	na					74	2					-	37	-	37			1.542	7	0.676	7
V733 Sco	n or m	7.5	1															-	7	-	7
V734 Sco	n or m	5.3	1															-	7	-	7
V787 Sgr	nr:	11.2	1			74	2					-	37	-	37						
V794 Oph	nb	6.3	1			220	51					-	37	-	37			0.797	7	0.182	7
V802 Cen	n	9.4	1																		
V825 Sco	n	7	1																		
V827 Her	na	10.6	1			60	2														
V838 Her	na	10	1	0.298	1	3	2	5000	76	Yes	58			Ne V	59	-	7	-	7	Mass	10
V840 Oph	nr:	12.8	1			36	2														
V841 Aql	n									No	37	-	37								
V843 Oph	nb	9.3	1	0.601	1	130	2					-	37	-	37			0.39	S	0.14	S
V862 Cen	n	11.2	1			48	51	1000	31												
V849 Oph	nb	9.7	1	0.173	1	175	2					No	37	Fe II	37						
V868 Cen	n	9.7	1			9	2														
V886 Cen	na	8.8	1																		
V902 Sco	nb	9	1																		
V906 Oph	na					25	2														
V908 Oph	n											-	37	-	37						
V909 Sgr	na	13.2	1			7	2					-	37	-	37						
V927 Sgr	na	12	1			15	2					-	37	-	37						
V928 Sgr	nb	11.6	1			100	2					No	37	Fe II	37						
V960 Sco	n	9.5	1																		
V970 Oph	nb	9.5	1			176	2											0.672	7	0.315	7
V977 Sco	n	11.6	1			8	2											0.617	7	0.14	7
V980 Sgr	nb:					24	37					-	37	-	37						
V992 Sco	na	8.9	1	0.156	1	120	2					-	37	-	37						
V999 Sgr	nb	9.4	1			160	2					-	37	-	37						
X Ser	nb:					170	2					-	37	-	37						
X Ser	na	9.4	1	1.680	1	-	-	611	23	-	37	-	37	-	37			0.63	S	0.45	S
XX Tau	na	12.6	1			51	3			-	37	-	37								