Can the Friction of the Nova Envelope Account for the Extra Angular Momentum Loss in Cataclysmic Variables (CVs)?

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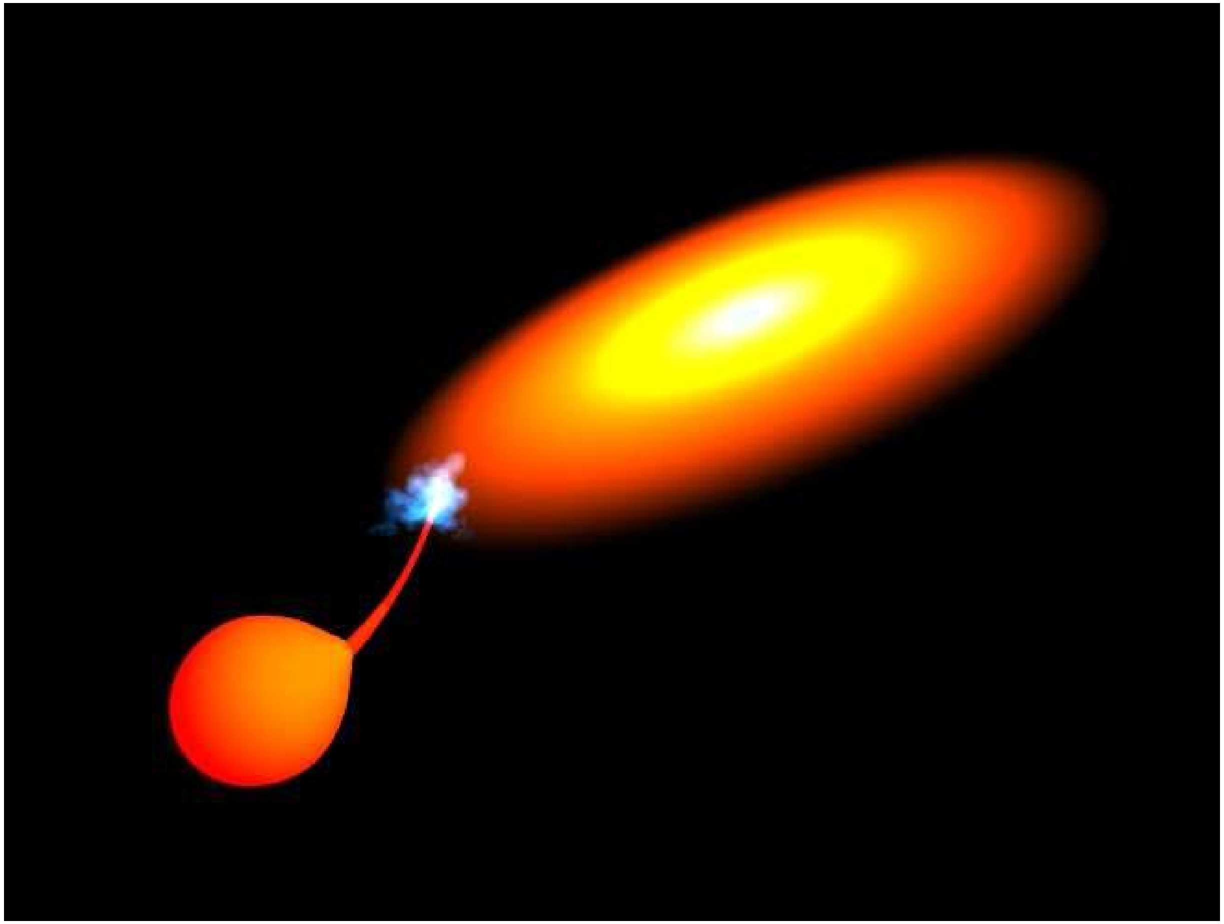
CVs are also WD binaries!

Features:

1) mass transfer

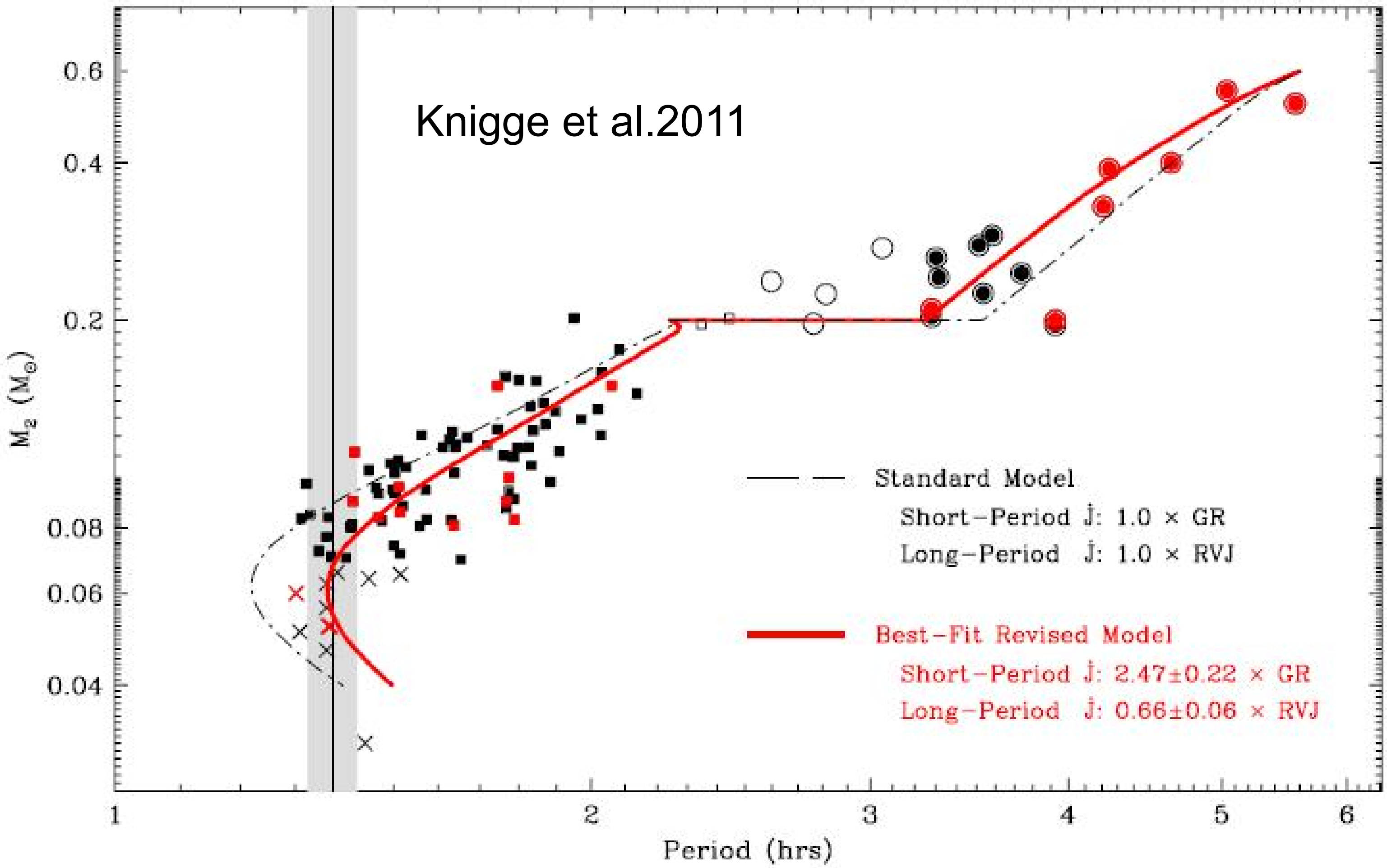
2) $M_{donor} < M_{wd}$

3) $P_{orb} < 1$ day



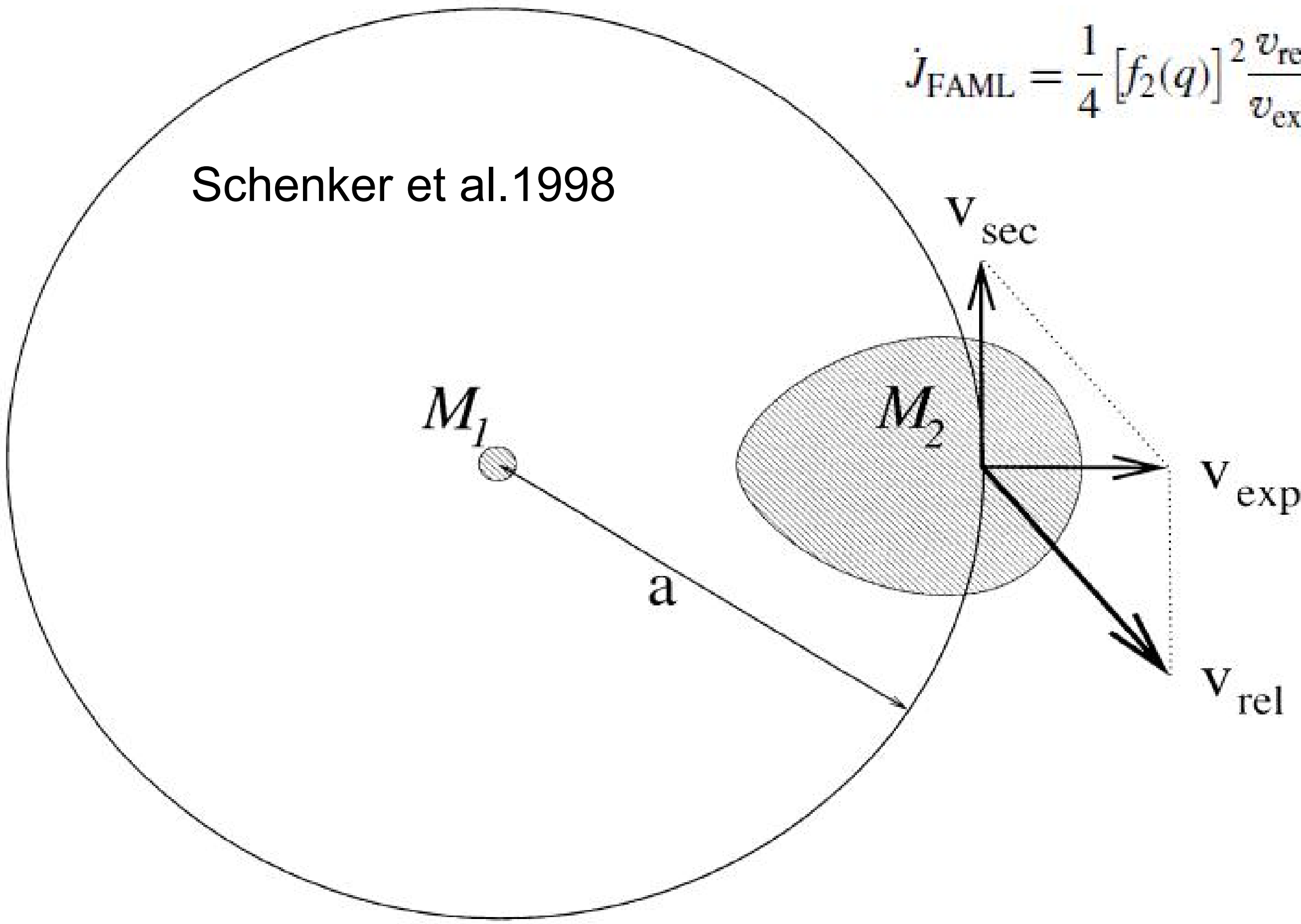
Credit: http://cronodon.com/SpaceTech/CVAccretionDisc.html

Background: below the period gap,the predicted J_dot=2.47J_dot_GR



Model: FAML(frictional angular momentum loss)

$$\dot{J}_{\mathrm{FAML}} = \frac{1}{4}\left[f_2(q)\right]^2 \frac{v_{\mathrm{rel}}}{v_{\mathrm{exp}}} \dot{M}_1 \sqrt{GMa}.$$



Schenker et al.1998

Purpose of this work (Based on MESA)

- To examine whether this FAML can solve the extra AML problem and the orbital period discrepancy.(observations [~80 mins] VS. predictions [65-70 mins])

Results

Table 1
The Calculated Results for the Traditional Evolution of CVs

M_2 ($M_\odot$)	$M_{WD,i}$ ($M_\odot$)	$M_{WD,f}$ ($M_\odot$)	$P_{orb,i}$ (days)	$P_{orb,min}$ (minutes)
0.4	0.5	0.5	0.316	67.55
0.4	0.5	0.5	0.501	67.52
0.4	0.5	0.5	0.794	67.42
0.5	0.5	0.545	0.316	67.85
0.5	0.5	0.548	0.501	67.84
0.5	0.5	0.547	0.794	67.76
0.6	0.5	0.534	0.316	67.79
0.6	0.5	0.537	0.501	67.79
0.6	0.5	0.538	0.794	67.74
0.6	0.8	0.8	0.316	69.18
0.6	0.8	0.8	0.501	69.16
0.6	0.8	0.8	1.0	68.91
0.8	0.8	0.8	0.316	69.18
0.8	0.8	0.8	0.501	69.16
0.8	0.8	0.8	1.0	68.97
1.0	0.8	0.8	0.316	69.19
1.0	0.8	0.8	0.501	69.18
1.0	0.8	0.8	1.0	68.96
0.6	1.1	1.1	0.316	70.35
0.6	1.1	1.1	0.501	70.32
0.6	1.1	1.1	1.0	70.05
0.8	1.1	1.1	0.316	70.35
0.8	1.1	1.1	0.501	70.32
0.8	1.1	1.1	1.0	70.07
1.0	1.1	1.1	0.316	70.35
1.0	1.1	1.1	0.501	70.34
1.0	1.1	1.1	1.0	70.03

Table 2
The Calculated Results for the Evolution of CVs with FAML for $v_{exp} = 40$ km s^{-1}

M_2 ($M_\odot$)	$M_{WD,i}$ ($M_\odot$)	$M_{WD,f}$ ($M_\odot$)	$P_{orb,i}$ (days)	$P_{orb,min}$ (minutes)	v_{exp} (km s^{-1})
0.4	0.5	0.541	0.316	69.12	40
0.4	0.5	0.539	0.501	69.08	40
0.4	0.5	0.538	0.794	68.97	40
0.5	0.5	0.549	0.316	69.18	40
0.5	0.5	0.553	0.501	69.17	40
0.5	0.5	0.549	0.794	69.07	40
0.6	0.5	0.584	0.316	69.37	40
0.6	0.5	0.586	0.501	69.36	40
0.6	0.5	0.585	0.794	69.30	40
0.6	0.8	0.8	0.316	70.36	40
0.6	0.8	0.8	0.501	70.33	40
0.6	0.8	0.8	1.0	70.12	40
0.8	0.8	0.8	0.316	70.36	40
0.8	0.8	0.8	0.501	70.34	40
0.8	0.8	0.8	1.0	70.12	40
1.0	0.8	0.8	0.316	70.37	40
1.0	0.8	0.8	0.501	70.36	40
1.0	0.8	0.8	1.0	70.14	40
0.6	1.1	1.1	0.316	71.44	40
0.6	1.1	1.1	0.501	71.42	40
0.6	1.1	1.1	1.0	71.16	40
0.8	1.1	1.1	0.316	71.45	40
0.8	1.1	1.1	0.501	71.42	40
0.8	1.1	1.1	1.0	71.12	40
1.0	1.1	1.1	0.316	71.46	40
1.0	1.1	1.1	0.501	71.44	40
1.0	1.1	1.1	1.0	71.14	40

Results

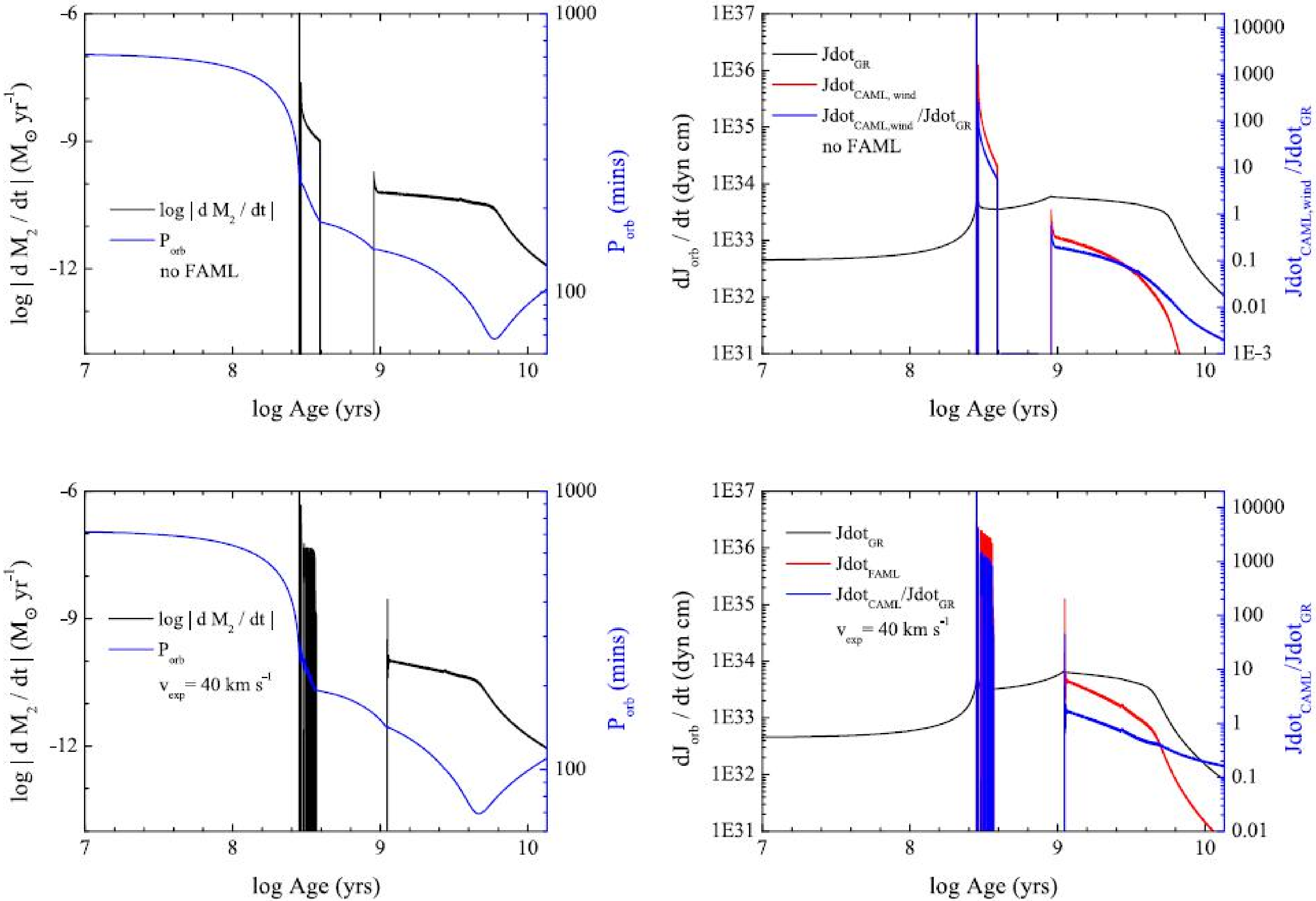
Table 3
The Calculated Results for the Evolution of CVs for $v_{exp} = 80$ km s^{-1}

M_2 ($M_\odot$)	$M_{WD,i}$ ($M_\odot$)	$M_{WD,f}$ ($M_\odot$)	$P_{orb,i}$ (days)	$P_{orb,min}$ (minutes)	v_{exp} (km s^{-1})
0.4	0.5	0.5024	0.316	68.20	80
0.4	0.5	0.5023	0.501	68.17	80
0.4	0.5	0.5021	0.794	68.07	80
0.5	0.5	0.5461	0.316	68.48	80
0.5	0.5	0.5464	0.501	68.46	80
0.5	0.5	0.5472	0.794	68.38	80
0.6	0.5	0.5795	0.316	68.67	80
0.6	0.5	0.5802	0.501	68.66	80
0.6	0.5	0.5803	0.794	68.60	80
0.6	0.8	0.8	0.316	69.74	80
0.6	0.8	0.8	0.501	69.72	80
0.6	0.8	0.8	1.0	69.52	80
0.8	0.8	0.8	0.316	69.75	80
0.8	0.8	0.8	0.501	69.73	80
0.8	0.8	0.8	1.0	69.52	80
1.0	0.8	0.8	0.316	69.76	80
1.0	0.8	0.8	0.501	69.75	80
1.0	0.8	0.8	1.0	69.54	80
0.6	1.1	1.1	0.316	70.88	80
0.6	1.1	1.1	0.501	70.85	80
0.6	1.1	1.1	1.0	70.61	80
0.8	1.1	1.1	0.316	70.88	80
0.8	1.1	1.1	0.501	70.85	80
0.8	1.1	1.1	1.0	70.54	80
1.0	1.1	1.1	0.316	70.88	80
1.0	1.1	1.1	0.501	70.87	80
1.0	1.1	1.1	1.0	70.59	80

Table 4
The Calculated Results for the Evolution of CVs for $v_{exp} = 200$ km s^{-1}

M_2 ($M_\odot$)	$M_{WD,i}$ ($M_\odot$)	$M_{WD,f}$ ($M_\odot$)	$P_{orb,i}$ (days)	$P_{orb,min}$ (minutes)	v_{exp} (km s^{-1})
0.4	0.5	0.5006	0.316	67.82	200
0.4	0.5	0.5006	0.501	67.79	200
0.4	0.5	0.5005	0.794	67.68	200
0.5	0.5	0.5465	0.316	68.11	200
0.5	0.5	0.5471	0.501	68.09	200
0.5	0.5	0.5478	0.794	68.02	200
0.6	0.5	0.5376	0.316	68.06	200
0.6	0.5	0.5386	0.501	68.05	200
0.6	0.5	0.5382	0.794	68.00	200
0.6	0.8	0.8	0.316	69.41	200
0.6	0.8	0.8	0.501	69.39	200
0.6	0.8	0.8	1.0	69.11	200
0.8	0.8	0.8	0.316	69.41	200
0.8	0.8	0.8	0.501	69.39	200
0.8	0.8	0.8	1.0	69.17	200
1.0	0.8	0.8	0.316	69.42	200
1.0	0.8	0.8	0.501	69.41	200
1.0	0.8	0.8	1.0	69.20	200
0.6	1.1	1.1	0.316	70.56	200
0.6	1.1	1.1	0.501	70.54	200
0.6	1.1	1.1	1.0	70.26	200
0.8	1.1	1.1	0.316	70.56	200
0.8	1.1	1.1	0.501	70.54	200
0.8	1.1	1.1	1.0	70.28	200
1.0	1.1	1.1	0.316	70.57	200
1.0	1.1	1.1	0.501	70.55	200
1.0	1.1	1.1	1.0	70.28	200

Mdonor,i=0.6Msun, Mwd,i=0.5Msun, Porb,i=0.5day



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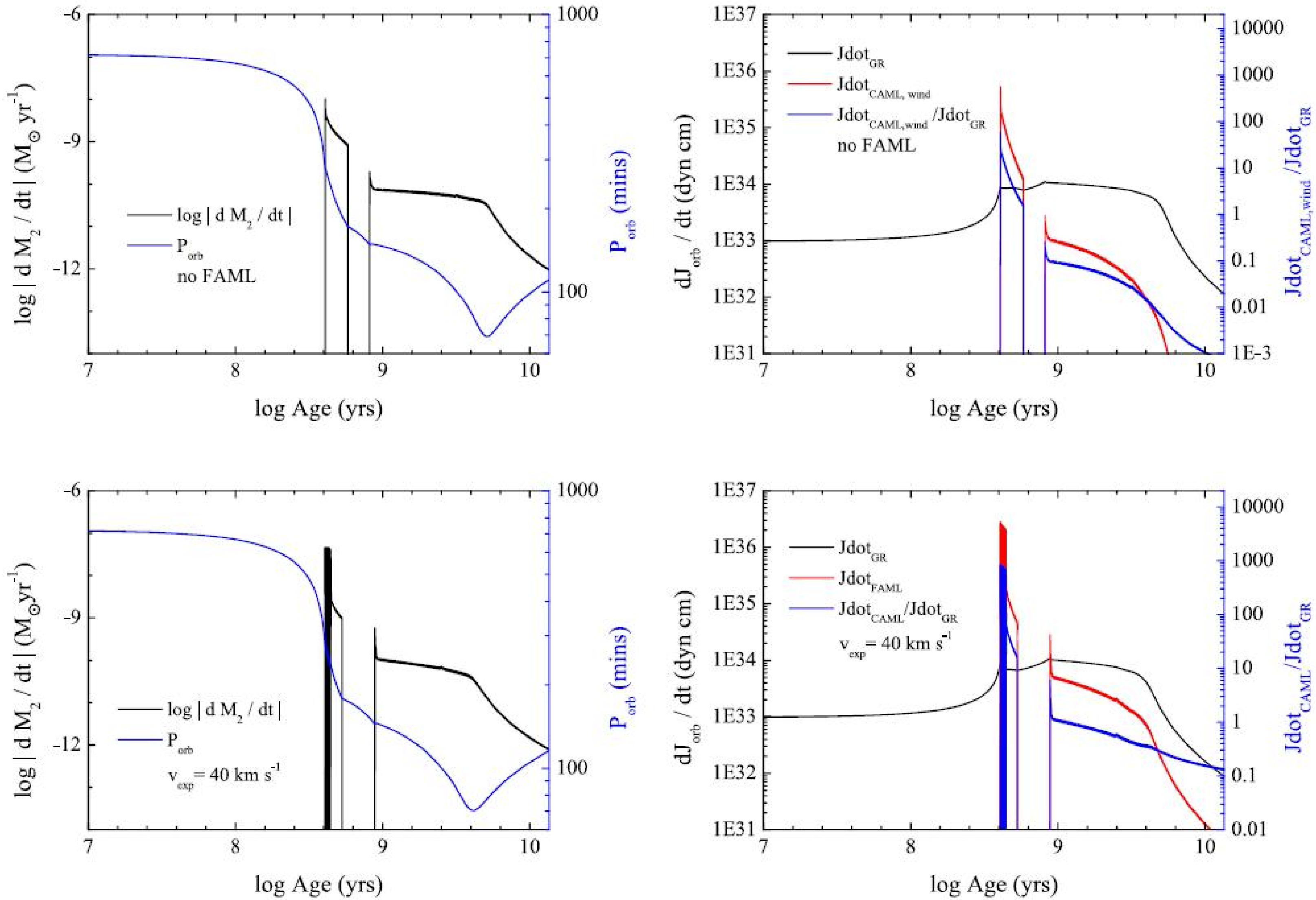
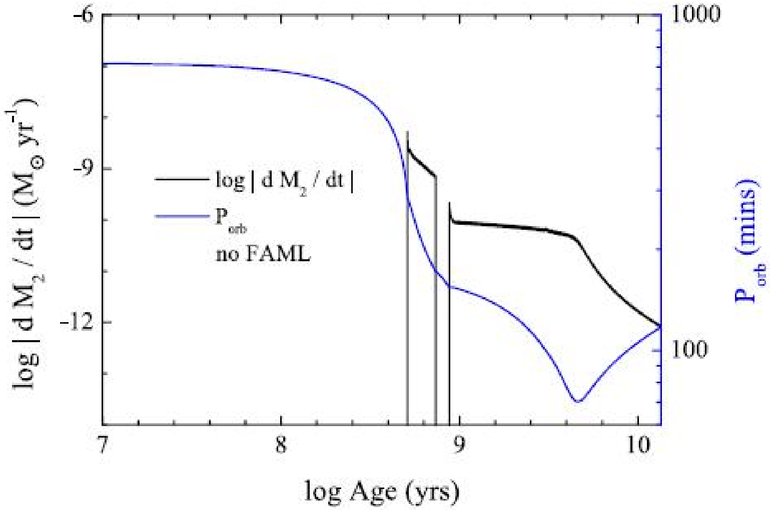
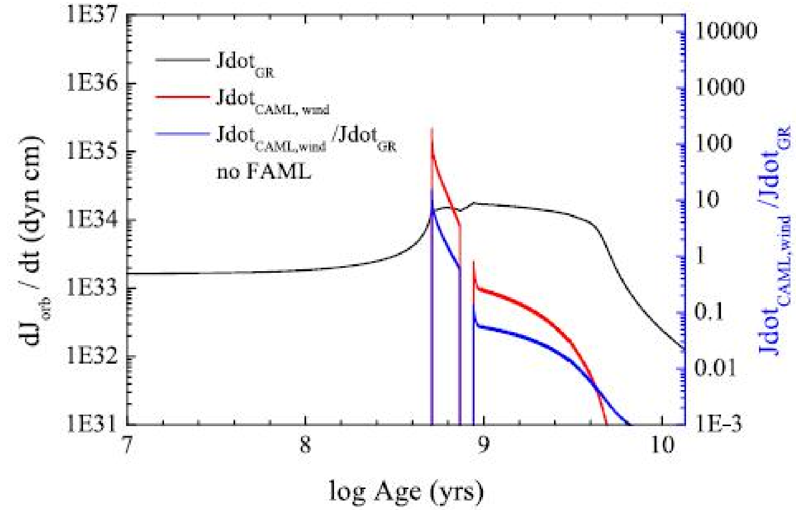
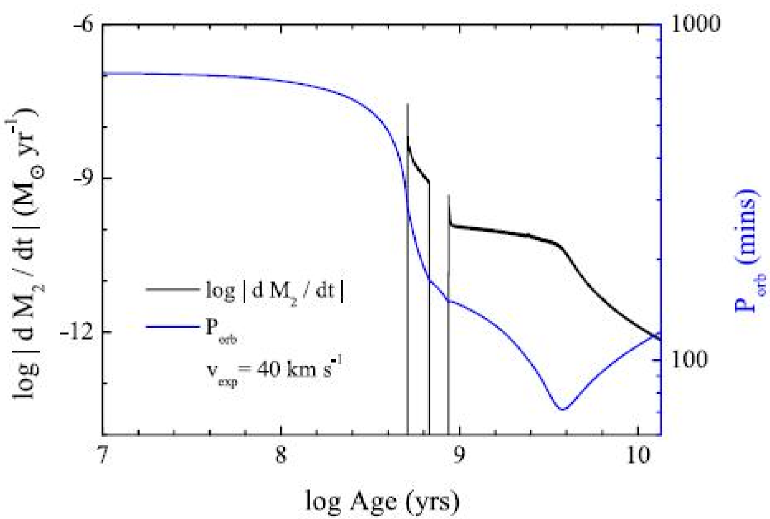
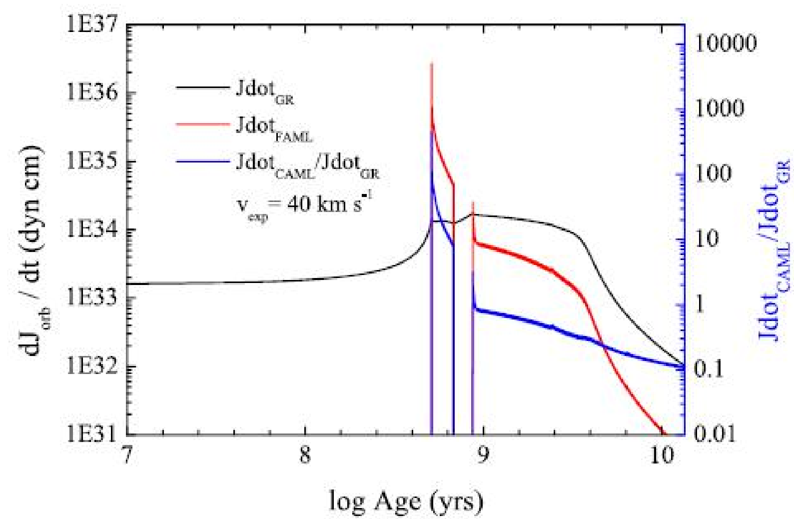


Mdonor,i=0.6Msun, Mwd,i=1.1Msun, Porb,i=0.5day



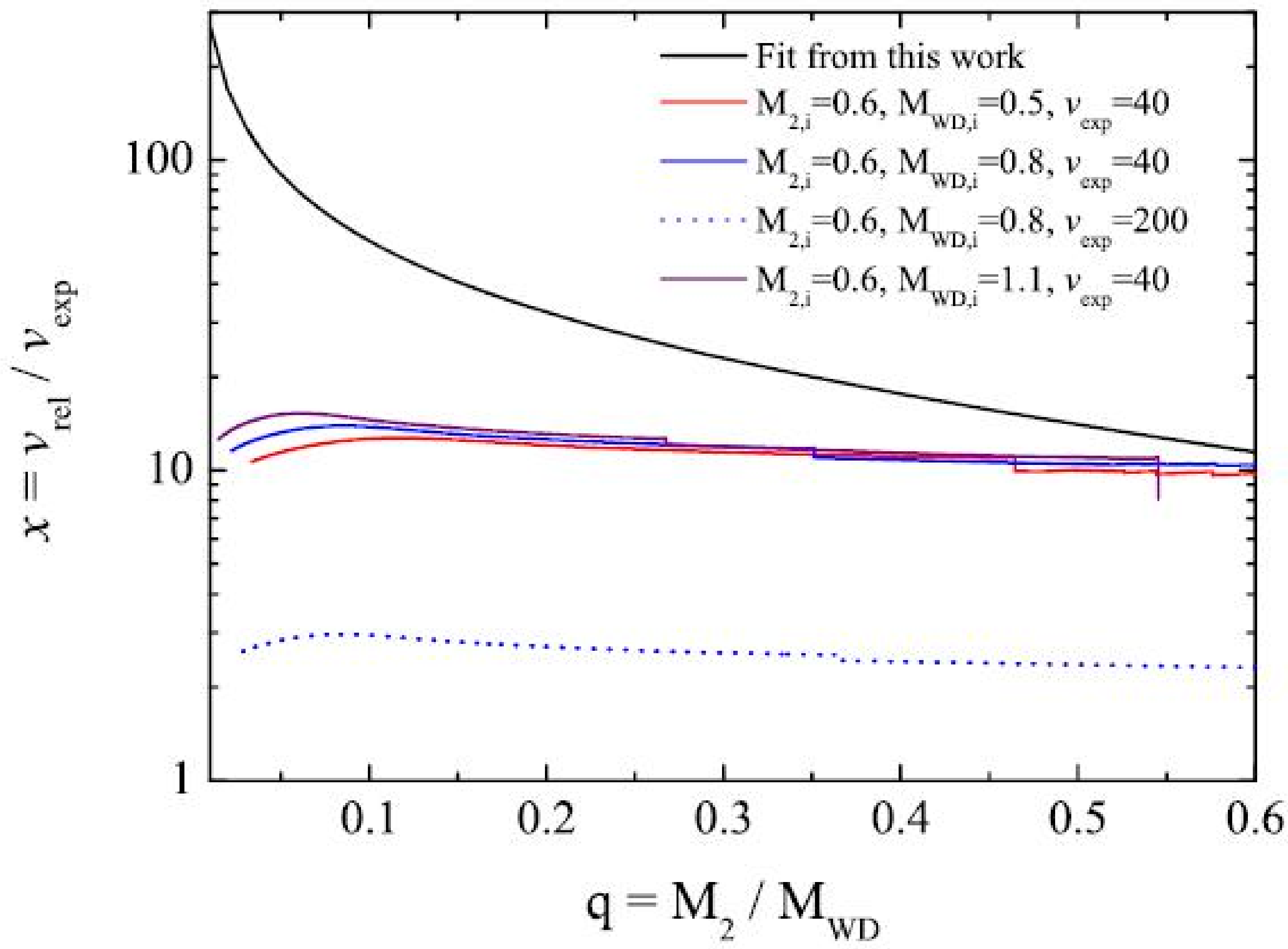






Discussion: Prediction and our fit for x

$$x = \frac{(0.496 + 0.297\zeta) - \frac{q(1.47+3q)}{2.47 \times 3(1+q)}}{\frac{(1+q)}{4}\left[\frac{8q}{81(1+q)}\right]^{2/3}}$$



Conclusions

(1) FAML effect seems unable to account for the extra AML, except when the nova envelope has extremely low expanding velocities. (that is impossible for the real actual situations)

(2) FAML has a very limited influence on the minimum orbital period distribution of CVs.