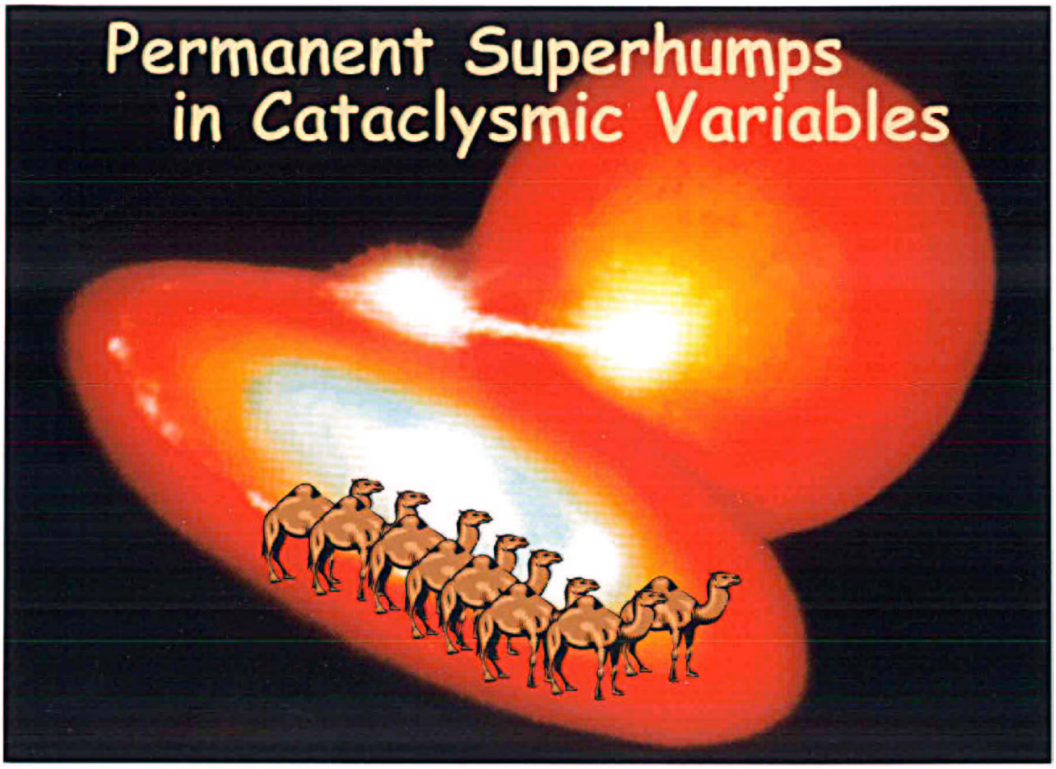


TABLE 1
PERIODS OF POSITIVE SUPERHUMPERS

Star	P_{orb} (days)	P_{sh} (days)	ε	Star	P_{orb} (days)	P_{sh} (days)	ε
AM CVn*	0.011906(1)	0.012166(1)	0.0218(1)	V1504 Cyg	0.06951(5)	0.07230(15)	0.0401(20)
CR Boo	0.017029(2)	0.01723(2)	0.0117(12)	CY UMa	0.06957(4)	0.07210(9)	0.0364(14)
CP Eri	0.019690(3)	0.019862(5)	0.0087(4)	FO And	0.07161(18)	0.0741(2)	0.0349(40)
V485 Cen	0.040995(1)	0.04216(2)	0.0284(5)	VZ Pyx	0.07332(3)	0.07576(15)	0.0333(20)
DI UMa	0.054564(2)	0.05529(3)	0.0133(5)	CC Cnc	0.07352(5)	0.0771(2)	0.0487(27)
V844 Her	0.054643(7)	0.05597(5)	0.0243(9)	HT Cas	0.07364721(1)	0.0761(2)	0.0330(30)
LL And	0.055053(5)	0.0567(2)	0.0296(36)	VW Hyi	0.07427104(1)	0.07673(6)	0.0331(8)
AL Com	0.0566684(1)	0.05735(3)	0.0120(7)	Z Cha	0.07449926(1)	0.07721(7)	0.0364(9)
WZ Sge	0.05668785(1)	0.05714(4)	0.0080(6)	WX Hyi	0.0748134(2)	0.0774(1)	0.0346(14)
SW UMa	0.05681(14)	0.05820(6)	0.0245(27)	BK Lyn*	0.07498(5)	0.07857(1)	0.0479(7)
HV Vir	0.05711(6)	0.05833(5)	0.0214(11)	AW Gem	0.07621(10)	0.07943(15)	0.0422(27)
MM Hya	0.057590(1)	0.05865(6)	0.0184(10)	SU UMa	0.07635(5)	0.07877(6)	0.0317(12)
WX Cet	0.05829(4)	0.05936(3)	0.0183(8)	HS Vir	0.07696(17)	0.0808(1)	0.0499(23)
EG Cnc	0.05997(9)	0.06037(3)	0.0067(8)	V503 Cyg	0.0777(2)	0.08104(7)	0.0430(27)
T Leo	0.058819(7)	0.06021(8)	0.0236(14)	V1974 Cyg*	0.08126(1)	0.08509(8)	0.0471(10)
AQ Eri	0.06094(6)	0.06267(13)	0.0284(21)	TY PsA	0.08414(18)	0.08765(12)	0.0417(22)
CP Pup*	0.06145(6)	0.0625(1)	0.0171(20)	DV UMa	0.0858527(1)	0.08875(20)	0.0337(24)
V1159 Ori	0.06218(1)	0.06417(7)	0.0320(11)	YZ Cnc	0.0868(2)	0.09160(15)	0.0553(26)
V2051 Oph	0.062428(1)	0.06385(10)	0.0228(16)	GX Cas	0.0889(3)	0.09302(7)	0.0463(36)
V436 Cen	0.0625(2)	0.06383(8)	0.0212(32)	V348 Pup*	0.101839(1)	0.1084(4)	0.0640(40)
HO Del	0.0625(3)	0.0644(2)	0.0304(50)	V795 Her*	0.108265(1)	0.1165(1)	0.0760(10)
VY Aqr	0.06309(4)	0.06437(9)	0.0203(15)	V592 Cas*	0.115063(1)	0.12226(6)	0.0625(5)
OY Car	0.0631209(1)	0.06440(10)	0.0203(15)	TU Men	0.1172(2)	0.1256(2)	0.0717(32)
ER UMa	0.06366(3)	0.06566(8)	0.0314(11)	AH Men*	0.12721(6)	0.1385(2)	0.0887(16)
UV Per	0.06489(11)	0.06641(7)	0.0234(23)	TT Ari*	0.1375511(2)	0.1492(1)	0.0847(7)
SX LMi	0.06717(11)	0.06950(7)	0.0347(25)	V603 Aql*	0.1381(1)	0.1460(7)	0.0572(51)
SS UMi	0.06778(4)	0.07022(10)	0.0360(15)	PX And*	0.146353(1)	0.1595(2)	0.0898(14)
TY Psc	0.06833(5)	0.0707(1)	0.0347(15)	BH Lyn*	0.155875(1)	0.1666(5)	0.069(4)
IR Gem	0.0684(3)	0.0708(3)	0.0351(66)	CN Ori	0.1630(2)	0.1706(9)	0.047(6)

TABLE 2

PERIODS OF PERMANENT SUPERHUMPERS

A. Positive Superhumpers				B. Negative Superhumpers			
Star	P_{orb} (days)	P_{sh} (days)	ε	Star	P_{orb} (days)	P_{sh} (days)	ε
AM CVn	0.011906(1)	0.012166(1)	0.0218(1)	AM CVn	0.011906(1)	0.0117063(6)	–0.0168(1)
CR Boo*	0.017029(2)	0.01723(2)	0.0117(12)	V503 Cyg	0.0777(2)	0.07597(18)	–0.022(5)
CP Eri*	0.019690(3)	0.019862(5)	0.0087(4)	V1974 Cyg	0.08126(1)	0.07911(5)	–0.027(1)
CP Pup	0.06145(6)	0.0625(1)	0.0171(20)	V442 Oph	0.1243(7)	0.12090(8)	–0.027(5)
BK Lyn	0.07498(5)	0.07857(1)	0.0479(7)	AH Men	0.12721(6)	0.12356(6)	–0.029(2)
V1974 Cyg	0.08126(1)	0.08509(8)	0.0471(10)	DW UMa	0.136606(1)	0.1330(5)	–0.026(4)
V348 Pup	0.101839(1)	0.1084(4)	0.0640(40)	TT Ari	0.1375511(2)	0.1329(3)	–0.034(3)
V795 Her	0.108265(1)	0.1165(1)	0.0760(10)	V603 Aql	0.1381(1)	0.1343(3)	–0.028(2)
V592 Cas	0.115063(1)	0.12226(6)	0.0625(5)	PX And	0.146353(1)	0.1415(3)	–0.033(2)
AH Men	0.12721(6)	0.1385(2)	0.0887(16)	BH Lyn	0.155875(1)	0.1490(11)	–0.044(8)
TT Ari	0.1375511(2)	0.1492(1)	0.0847(7)	TV Col	0.22860(1)	0.2160(5)	–0.055(2)
V603 Aql	0.1381(1)	0.1460(7)	0.0572(51)				
PX And	0.146353(1)	0.1595(2)	0.0898(14)				
BH Lyn	0.155875(1)	0.1666(5)	0.069(4)				

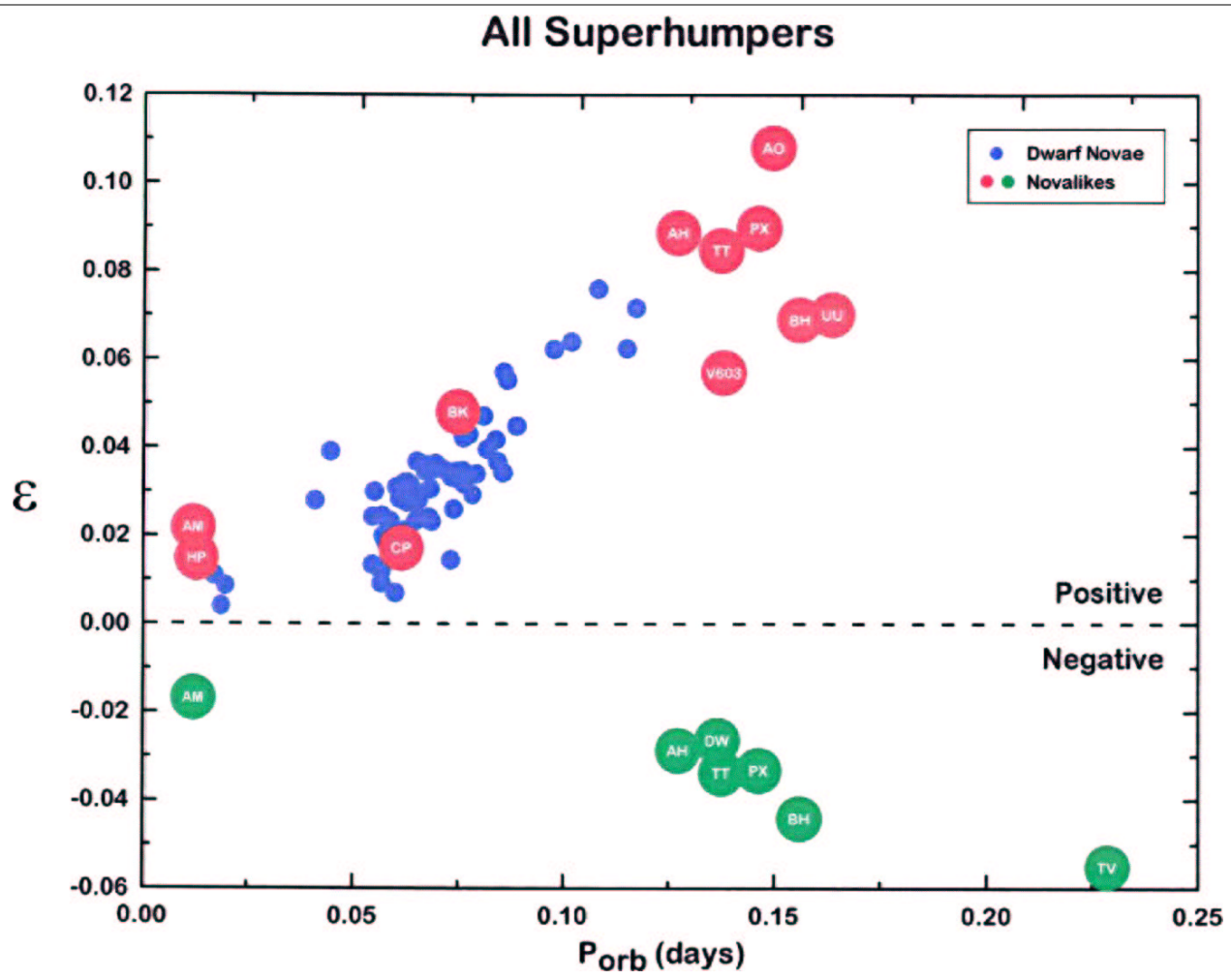
NOTE. — * Superhumps in these two helium stars are essentially common *and* permanent, as discussed in text.

MINIMUM REQUIREMENTS

> 50 hr coverage
> 10 d baseline
Periods unaliased, known to < 0.4%
Signals appeared more than once
Each apparition > 6σ

⇒ 14 positive
11 negative
7 are both < 4 switch, 3 co-habit

+ 58 COMMON SUPERHUMPS.



DRAMATIS PERSONAE

ω ORBITAL FREQUENCY

Ω (APSIDAL) PRECESSION FREQUENCY

N (NODAL) PRECESSION FREQUENCY

$\omega - \Omega$ +SUPERHUMP

$\omega + N$ -SUPERHUMP

The common beasts : signals at

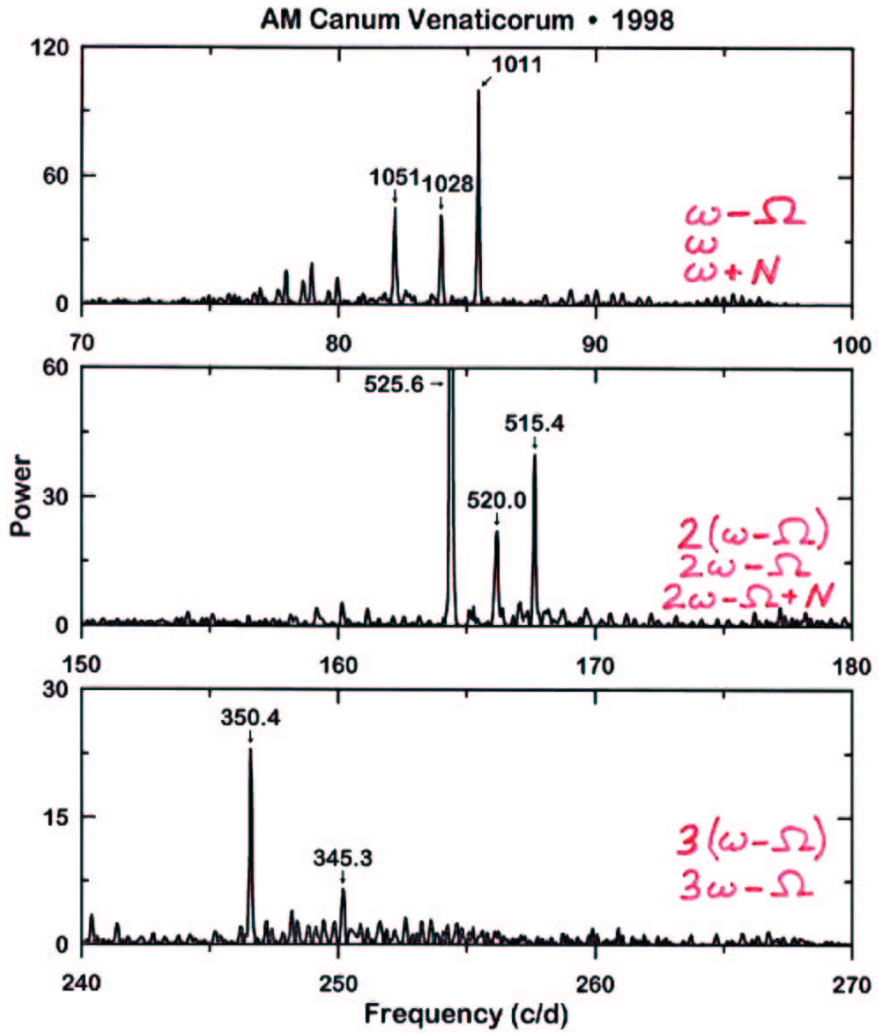
$\omega - \Omega$ $\quad$ N

$n(\omega - \Omega)$ $\quad$ $\omega + N$

$n\omega + N$

More exotic frequencies appear sometimes, at low amplitude:

$\boxed{n\omega - m\Omega}$ where $m = 1, 2, \ldots, n$



and $+N$ available as a BONUS frequency!

$\Rightarrow \boxed{n\omega - m\Omega}$

n = any integer

$m = 1, \ldots, n$

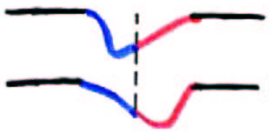
PRECESSION - THE EVIDENCE

NODAL

* Photometric wave at N
* Sidebands always +N
  ⇒ always retrograde
* $\varepsilon_{neg} \approx -0.5\,\varepsilon_{pos}$
* Simultaneous existence w/ apsidal

APSIDAL

* Skewness of lines modulated at Ω
  (AM CVn, CR Boo, assorted)



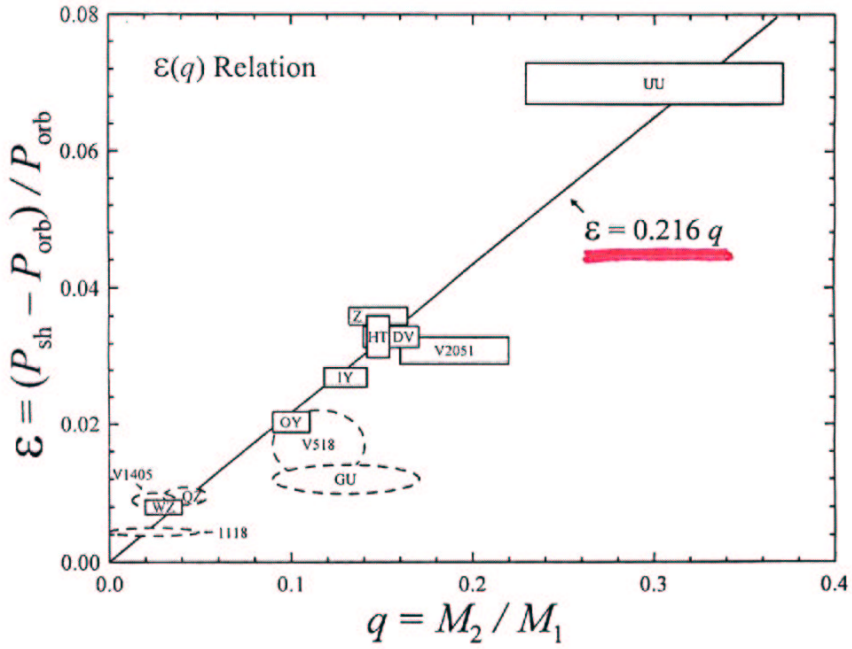
* Timing of spot + disk eclipses
  (OY Car, Z Cha)
* Probably limited to $q < q_{crit}$; agrees with theory condition for eccentric instability at 3:1
* Sidebands always $-\Omega$ ⇒ always prograde
* Works! Get modulation w/ ~0.1 mag

$$\varepsilon(q) \approx \frac{0.23\,q}{\sqrt{1+q}}$$

EMPIRICAL

1 particle

10^{47} particles



$$R_2/a = 0.46\left(\frac{m_2}{m_1+m_2}\right)^{1/3}$$

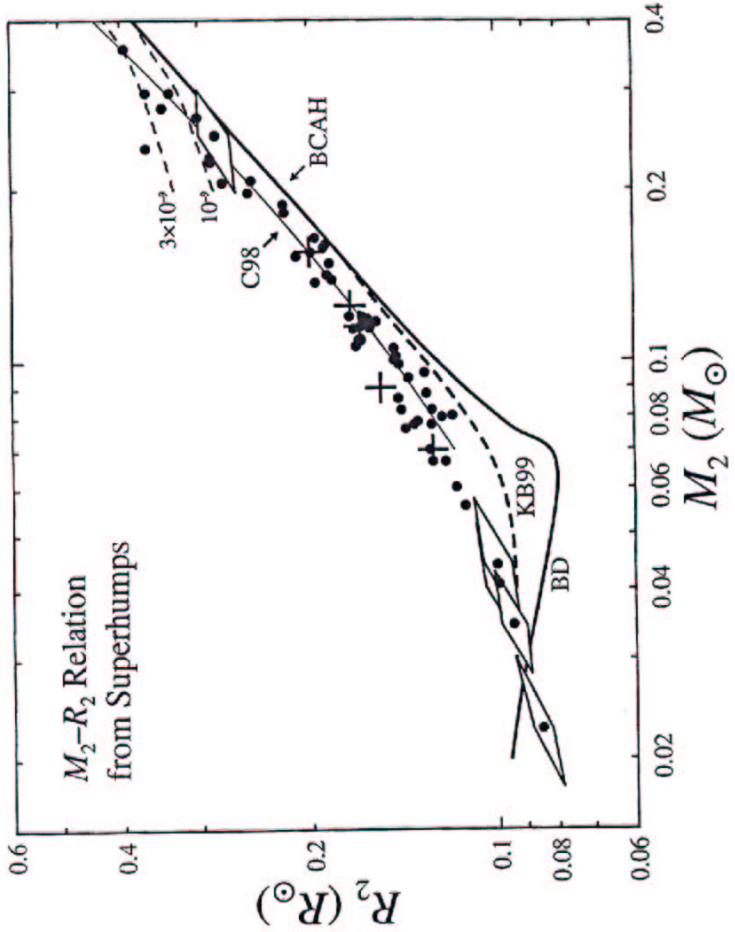
$$P^2 = \frac{4\pi^2}{G(m_1+m_2)}\,a^3$$

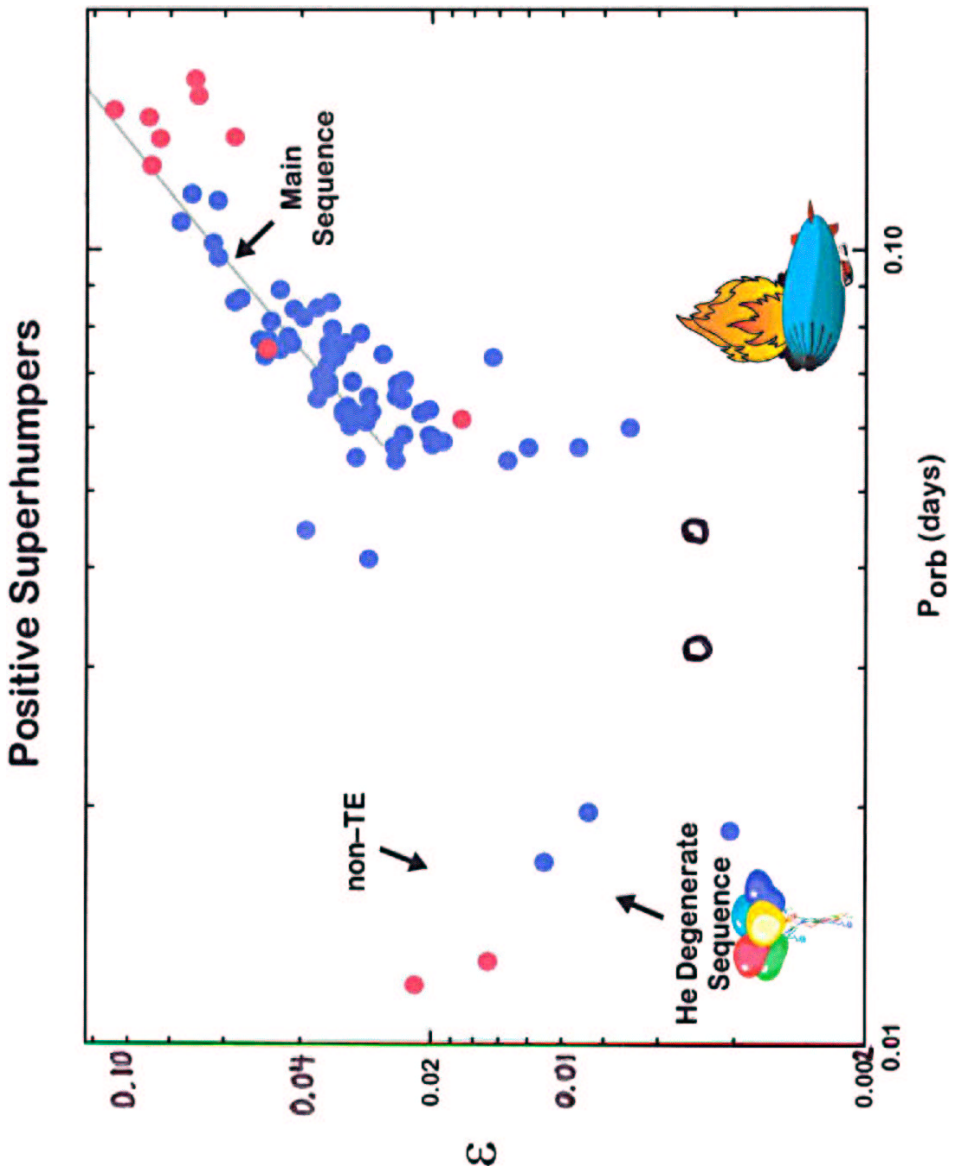
} 2 eqns, 4 unknowns

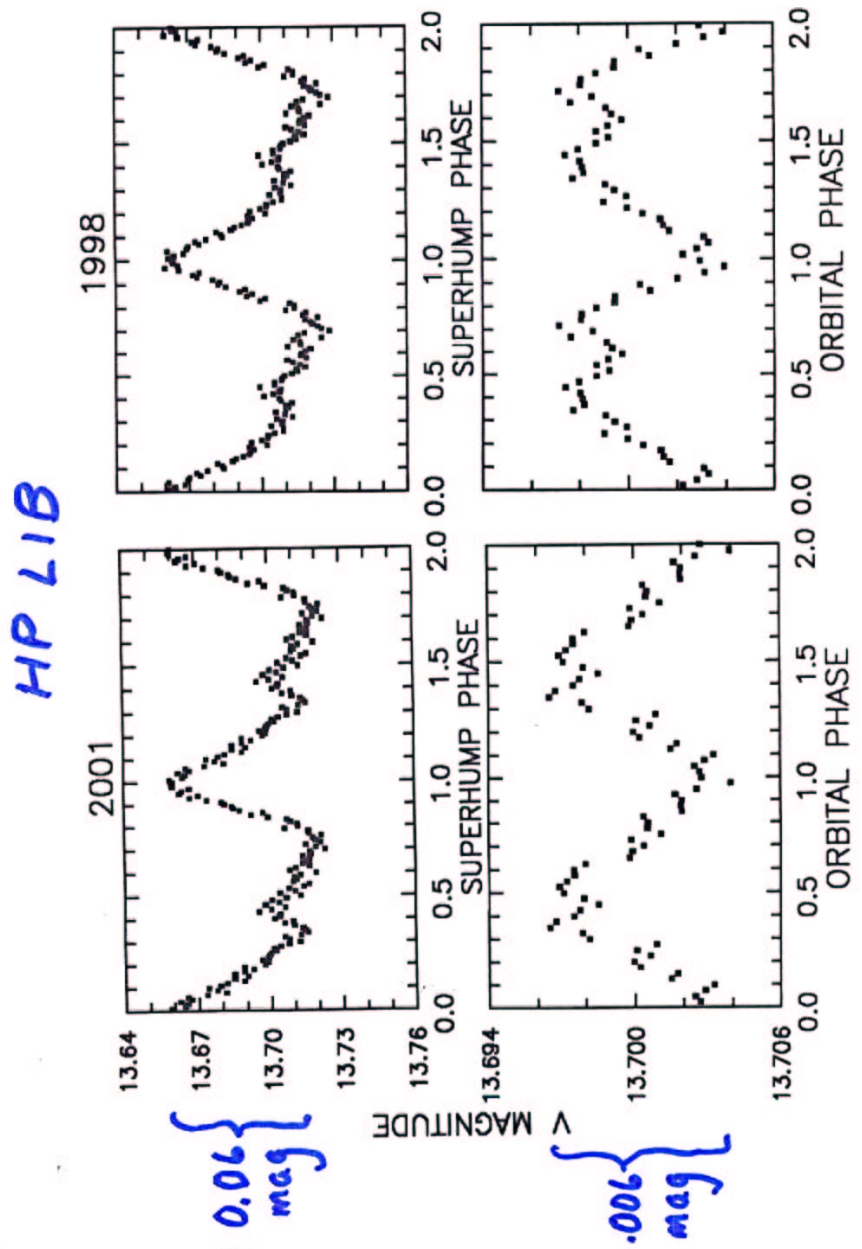
Get $q \equiv m_2/m_1$ from superhumps

⇒ $R_2(m_1)$ for each star

OR assume $R_2 = \alpha R_{RL}$, predict $\varepsilon(P_0)$


M_2–R_2 Relation
from Superhumps
3×10⁻³
10⁻³
C98
BCAH
KB99
BD
R_2 ($R_\odot$)
M_2 ($M_\odot$)
0.6
0.4
0.2
0.1
0.08
0.06
0.02
0.04
0.06
0.08
0.1
0.2
0.4


Positive Superhumpers
Main Sequence
non–TE
He Degenerate Sequence
ε
P_{orb} (days)
0.10
0.04
0.02
0.01
0.002
0.01
0.10



	Common ASH	Permanent ASH	ORB	NSH
ES Cet	–	.08	<.008	<.015
AM CVn	–	.024	.010	.02
HP Lib	–	.05	.007	<.005
CR Boo	.12	.05	.05?	<.01
V803 Cen	.10	.02	.010	<.02
CP Eri	.20	.02	.20	<.05
KL Dra	.15	dunno		
GP Com	←	<.02	→	
CE-315	←	<.04	→	

V803 Cen

$\omega_{sh} = 53.4$

disagrees