dominantly the light of the primary star. We agree that observations in a different spectral region are desirable, especially, perhaps, in the red and infrared regions where the light of a normal secondary component would be relatively stronger.

Gibbons and Hawking find an apparent secondary maximum in the frequency distribution of e for double-line binaries that seems to us interesting. In view of the selection effects discussed above, this secondary maximum must correspond to a real effect in the velocity curves, provided that it is statistically significant, which, of course, is doubtful in so small a sample. Because seven of the eight systems that form this maximum contain stars of early B spectral types (for which the concentration of circular orbits should be greater because Δ and Δ' are large for stars of this type) the most likely explanation appears to us to be that these velocity curves are distorted in a way analogous to that in which velocity curves of Algol-type systems are distorted.

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Drs Hawking and Gibbons write: The two main points that Batten and Olowin make about our paper are:

1. The measured eccentricities of short period binaries are unreliable and may not represent real eccentricities.

2. There may be a selection effect which makes the detection of higher eccentricities more likely in single-line binaries than in double-line binaries.

We must agree with the first point. Since our letter was published there has appeared a recomputation of 201 G Sgr (HD 184035), which was one of the single-line binaries which we suggested might contain a black hole in view of its reported eccentricity of 0.09. The new computation of Lucy and Sweeney[1], however, lowers this value to 0.049. If this is correct it seriously weakens our argument, because it reduces the number of single-line binaries in our sample with "high" eccentricities from 3 to 2 whereas one would expect 1 on average, if the distribution of eccentricities for single-line binaries were the same as that for double-line binaries (but see Gott[2], succeeding communication).

Although measured eccentricities may be rather unreliable, we do not see any obvious reason why these should favour single line rather than double-line binaries. The selection effect mentioned by Batten and Olowin would appear to us to be small—indeed they admit as much when they say "its total effect in a large sample should not be large". Surely a selection effect which has a small effect in a large sample will have a small effect in any sample. The possibility of statistical fluctuations in a small sample is a separate problem.

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Further Evidence for Collapsed Objects in Binary Star Systems

IT would be of great interest to discover a collapsed object (neutron star or black hole) as one component of a binary star system. Trimble and Thorne[1] have compiled a list of fifty candidate systems from Batten's[2] catalogue. These are non-eclipsing single-line spectroscopic binaries in which the unseen companion has a mass estimated to be greater than 1.4 $M_\odot$. These unseen companions are thus too massive to be non-rotating white dwarfs (although the possibility that they are rapidly, differentially rotating white dwarfs cannot be completely excluded as Ostriker and Bodenheimer[3] have shown). In principle, some of these unseen companions could be neutron stars or black holes. In most cases, including all those to be considered here, the unseen companion is less massive than the observed primary star and can be a normal main-sequence star, which is not observed simply because it is considerably less luminous than the primary. Recently, however, Gibbons and Hawking[4] have presented evidence that suggests that one or more of the systems on the Trimble and Thorne list contain collapsed objects. Their argument is as follows. Let the initial binary system consist of two stars with masses M_1 and M_2. Let the more evolved star (M_1) eject some of its mass and collapse to form a neutron star or black hole with gravitational mass M_{N1}. The ejected mass-energy can be in the form of a shell of matter or gravitational radiation, for example. If the initial orbit is circular and the mass loss can be treated as instantaneous and spherically symmetric, then the resultant binary system (M_2, M_{N1}) will have an orbital eccentricity given by

$$e = \frac{M_1 - M_{N1}}{M_2 + M_{N1}} \qquad (1)$$

(Note: the notation for the star masses above is not the usual notation for spectroscopic binaries.) Three of the seven systems from the Trimble and Thorne list with $P<5$ days were found to have $e>0.08$. By a comparison with short-period double-line binaries Gibbons and Hawking concluded that the probability of this occurring by chance is only 8%. This suggests that in one or more of the three systems, the eccentricity arises from a sudden mass loss and that the unseen companion is a collapsed object rather than a main-sequence star.

Table 1 Single-line Binaries from the Trimble and Thorne List with $P<5$ Days, $e<0.13$

Star	Spectral type	Aprox-imate distance	Period (days)	e	Corrected radial velocity V_R (km s^{-1})	$\frac{\lvert V_R\rvert}{\langle V_r^2\rangle^{\frac{1}{2}}}$
HD 40005	B3V	430 pc	3.306	(0.037)	+5	0.5
201 G Sgr	A3III	140 pc	4.625	(0.049)	+18	1.2
HD 191473	B0.5V	1,500 pc	4.2876	0.070	+2	0.2
HD 198784	B3	440 pc	3.30353	(0.024)	+10	1.1
HD 209961	B2V	460 pc	2.1721	(0.0)	−3	0.3

These results must be revised somewhat in light of the recent work by Lucy and Sweeney[5] which indicates that the originally quoted value of $e=0.9$ for 201 G Sgr was entirely the result of observational error. Tables 1 and 2 tabulate the relevant data for the 7 binaries with $P<5$ days from the Trimble and Thorne list. Eccentricity lata are taken from Lucy and Sweeney whenever possible. A value in parentheses indicates that a circular orbit is compatible with the observational data. We note that the data for HD 176318 and HD 194495 are sufficiently accurate to assure that these are in fact high eccentricity systems. Following the procedure of Gibbons and Hawking, we select for comparison double-line binaries with $P<5$ days, with both components >1.4 $M_\odot$, with observational quality a to d in Batten's system, and for which the eccentricity was not assumed to be zero. We likewise exclude