Gravitational scale factor and quantum gravitational effects in relative evolutionary expansion of components of detached double-lined eclipsing systems (DDLESes)

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Introduction. The DDLES is consists of two very close stars which are the first and second components. Indexes 1 and 2 indicate the first and second components, respectively. M and R are the mass and radius of the component, respectively, H is the quantum gravitational constant which is 145.5 km/s. In addition $g = GM/R^2$ and is determined in cm/s^2, as it is assumed in astrophysics.

If a quantum gravitational effect is carried out along the coordinate axis of the ratio of the values of any parameter of the first and second components, then it is of the second type. The distributions of the DDLESes and its components are constructed using empirical data from catalogs [1 - 4].

Part. 1. Gravitational scale factor. Figure 1 shows the distribution of the DDLES components. For groups of the components of different ages, isochrones are indicated by the dotted lines.

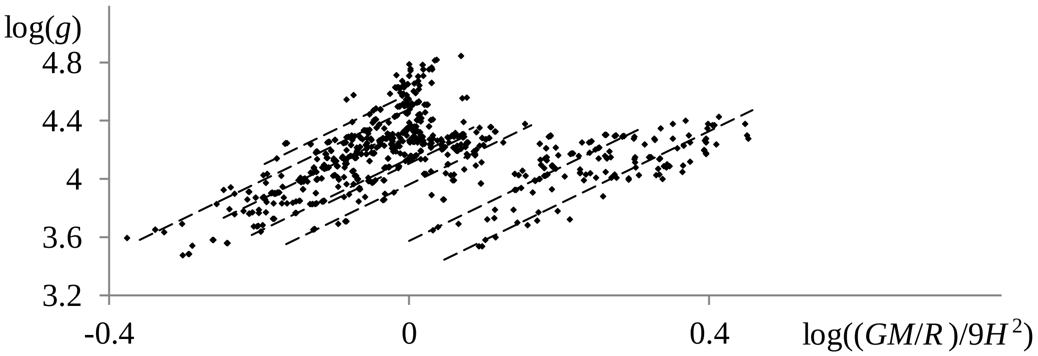

Figure 1. The distribution of 864 components of the detached double-lined eclipsing systems.

For each of the isochrones

$$\log g = (5/2)\log((GM/R)/9H^2) + b,$$

where b is some time parameter. It corresponds to $R \propto M^3$ for the DDLES component.

Figure 2 shows the distribution of the DDLESes. The first (■), second (◇), third (◆) groups, the common stars of these groups (○), as well as the fourth (△) and fifth (▲) groups are highlighted.

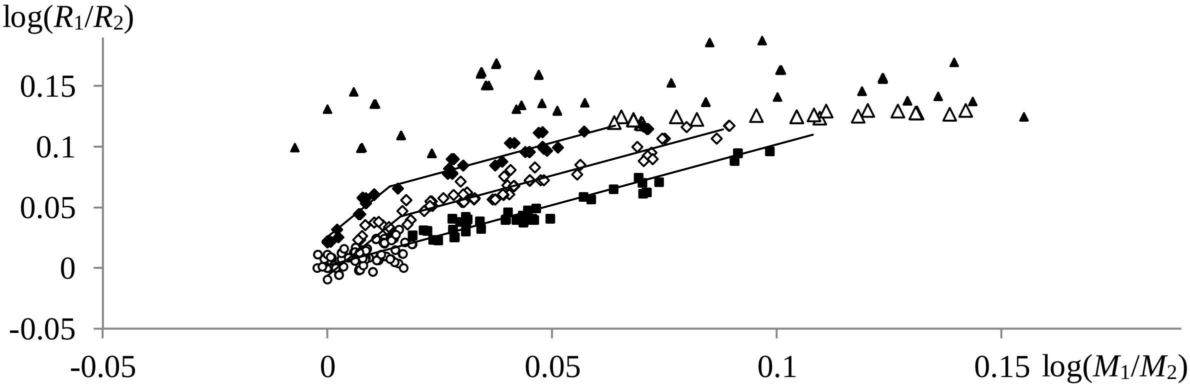

Figure 2. The distribution of 373 components of the detached double-lined eclipsing systems.

$R_1/R_2 \propto (M_1/M_2)^3$ is valid only for 27% of the DDLESes. Moreover, this dependence exists with an increase in M_1/M_2 only up to (1.025 – 1.042) and in the second and third groups. Then it becomes true $R_1/R_2 \propto M_1/M_2$, and for 53% of the DDLESes.

This is the consequence of the action of the gravitational scale factor M_1/M_2. Namely,

$$R_1 = \kappa_1 M_1^3/(M_1/M_2)^\omega \quad (1a)$$

$$R_2 = \kappa_2 M_2^3(M_1/M_2)^\omega \quad (1b)$$

where κ is the reduced radius, depending on the age of the components, but not on M_1/M_2, ω is a positive parameter, $M_1/M_2 \geq 1$. Taking into account (1) $\omega = 1$ for the first group and, when $M_1/M_2 \geq 1.042$, for the second and third groups. For the fourth group $R_1/R_2 \propto$ const. Hence, $\omega = 1.5$. Thus, when M_1/M_2 and R_1/R_2 increase, the transition ω from 1 to 1.5 occurs and, thereby, the amplification of the action of the gravitational scale factor takes place.

Part. 2. Quantum gravitational effects of the second type. For $M_1/M_2 \geq 1.042$ and $\omega = 1$, the first, second, and third groups are located with the same step along the coordinate axis $\log(R_1/R_2)$. This is the consequence of the action of the quantum gravitational effect of the second type along the coordinate axis $\log((GM/R)_1/(GM/R)_2)$ in the relative evolutionary expansion of the first and second components. Figure 3 shows the distribution of the DDLESes along this axis.

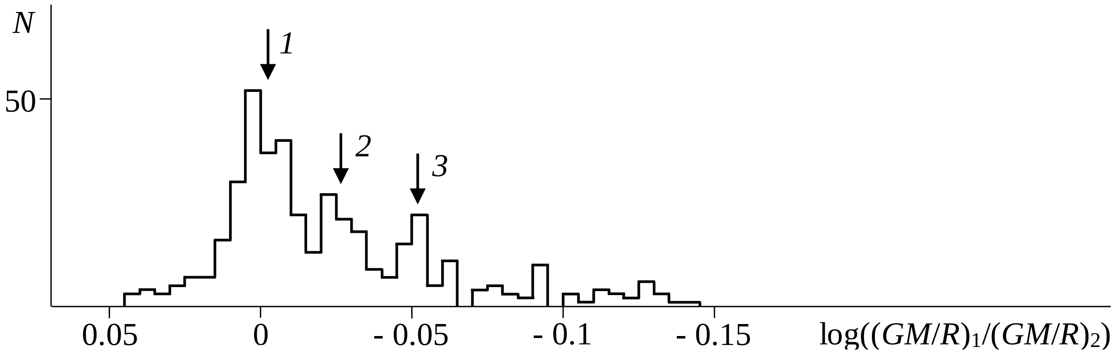

Figure 3. The distribution of 422 detached double-lined eclipsing systems.

Three peaks are visible, the positions of which are determined as

$$\log((GM/R)_1/(GM/R)_2) = - 0.0248n - 0.0022, \; n = 0, 1, 2$$

Figure 4 shows the distribution of the DDLESes along the coordinate axis $\log(R_1/R_2)$.

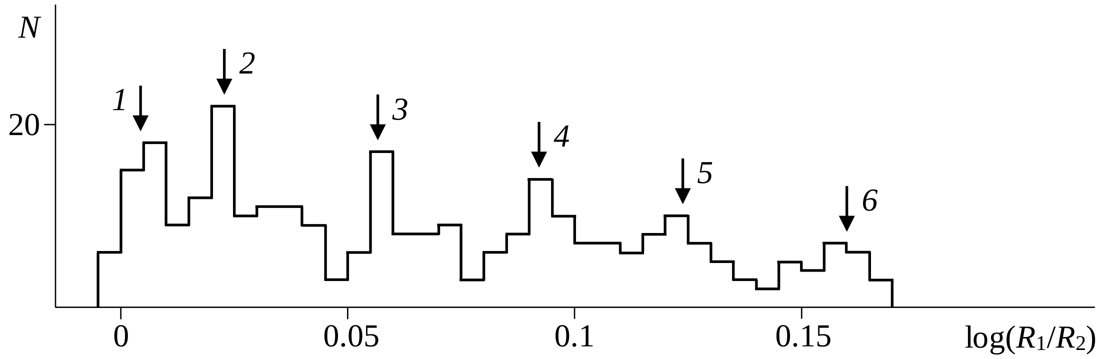

Figure 4. The distribution of 295 detached double-lined eclipsing systems.

Six peaks are visible, the positions of which are determined as

$$\log(R_1/R_2) = 0.0085n - 0.0027, \; n = 0, 3, 7, 11, 15, 19 \quad (2)$$

Hence, the quantum gravitational effect of the second type exists along the coordinate axis $\log(R_1/R_2)$. The quantum gravitational effect of the second type is also found along the axis $\log(g_1/g_2)$.

Note that, according to (2) along the coordinate axis $\log(R_1/R_2)$, the distance between the nearest populated areas increases by a multiple of the quantization step with increasing n. A similar change in this distance is also observed for the quantum gravitational effect of the second type along the coordinate axis $\log(g_1/g_2)$.

Conclusion:

1. In figures 3 and 4 the peaks are created by the populated areas of the temporal coordinated evolutionary expansion of the first and second components.
2. The relative evolutionary expansion of the first and second components is, in particular: their transitions along the coordinate axes $\log((GM/R)_1/(GM/R)_2)$, $\log(R_1/R_2)$ and $\log(g_1/g_2)$ between these areas and their temporary localization in the latter. In this case, the gravitational scale factor can additionally compress and expand, respectively, the first and second components. Therefore, the evolutionary expansion of the component is complicated, although orderly.

References

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