Spin Correlation in Visual Binaries

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Abstract

Using methods to circumvent selection effects, we find correlation between the projected rotational velocities (spins) in binary systems. In visual binaries this correlation is very strong. Moreover, the degree of correlation is independent of component separation. These results indicate the possibility that spin correlation in binaries is the result of evolutionary history, rather than that of tidal interaction. Studies of spin correlation in binaries could thus be an important tool in understanding the evolution of such systems.

Motivation

1. New, enlarged database enable us a more relaible analysis of previous studies.
2. Zahn (1970) indicates that the degree of synchronization in binaries depend on the separation between the components.
3. Develope methods for avoiding possible statistical biases that are the result of proximity in spectral type.
4. Can one restrict theories of binary evolution?

Data

Choice of data is given by Farbiash & Steinitz (2004). The salient points are: Spectral type of both components is earlier than F0; Giants and Supergiants are excluded, as well as multiple systems with more than two stars.

We use a set of Real Binaries, and a subset of Visual Binaries.

An apparent correlation could be the result of proximity in spectral type, again as a bias in detecting binaries as such. To avoid this (possible) bias, we generate a mixed binaries sample by forming Artificial Binaries composed of all stars in the original sample (regarded as single stars), and excluding the real ones.

From this last set, we extract all pairs whose members are closer than certain narrow range in spectral type. This is the Restricted Artificial Binaries set.

Results I

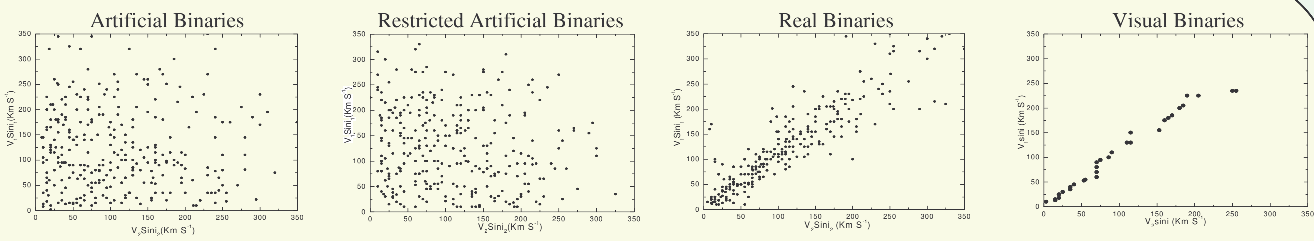

Figure set 1. *To illustrate correlation between projected rotational velocities in real binaries only, we plot the projected rotational velocities of one component against the other one, for all four samples. This figures indicate clearly that spin correlation is only present in real binaries. In addition we see from the Restricted Artificial Binary sample that spin correlation is not due to proximity in spectral type of members in a binary system.*

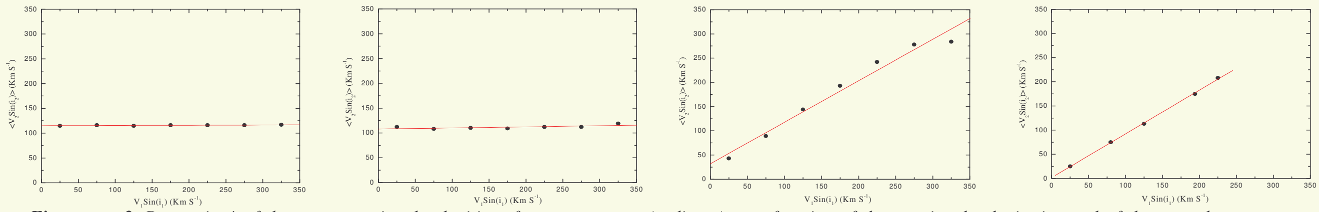

Figure set 2. *Regression* of the mean rotational velocities of one component (ordinate) as a function of the rotational velocity interval of the second component (abscissa) for all sets.*

$$* \quad \overline{v}\sin i_1\left(v\sin i_2\left(j\right)\right)=\frac{\sum_{n=1}^{7} v\sin i_1\left(n\right)F\left(v\sin i_1\left(n\right),v\sin i_2\left(j\right)\right)}{\sum_{n=1}^{7} F\left(v\sin i_1\left(n\right),v\sin i_2\left(j\right)\right)}$$

, here $F(v\sin i_1, v\sin i_2)$ *is the bivariate distribution.*

Results II

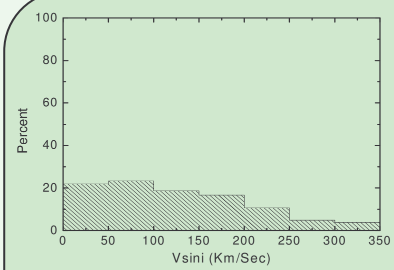

Figure 3. *Projected rotational velocity distribution of all components of binaries grouped into intervals of 50 km/s.*

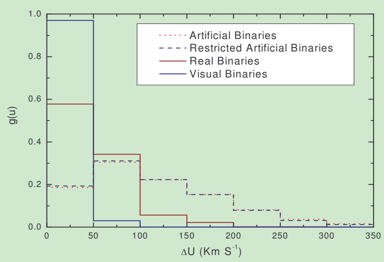

Figure 4. *Convolution of rotational velocities.*

$$g(u) = \sum_{v} F(v-u, v)$$

Results III

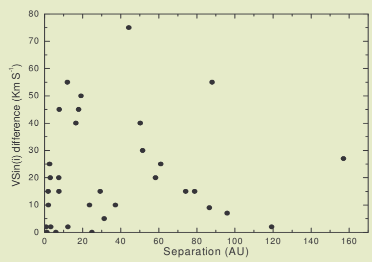

Figure 5. *Projected rotational velocity differences vs. separation of components for binaries whose separation is known.*

What Do We Conclude?

1. Spin correlation in binaries is not due to proximity in spectral type.
2. Spin correlation means that $v_1\ sini_1 \cong v_2\ sini_2$ and therefore $v_1 \simeq v_2$ as well as $sini_1 \simeq sini_2$.
3. Spin correlation in Visual Binaries is extremely significant.
4. The level of spin correlation does not depend on separation between the members.
5. The investigated systems where unlikely formed by three body collisions.

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References:

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