Group Card Activity, Sep. 25

Today we talked about three types of binary stars:
1. visual – where you see the stars move back and forth
2. eclipsing – where the combined brightness shows "dips" when one star moves in front of the other, and
3. spectroscopic binaries – where the spectral lines shift back and forth in wavelength due to the Doppler effect

(a) What causes a particular binary star system to fall into one of these categories?
(b) Can a given binary star belong to more than one of these categories? Explain.
(**Hint**: Recall the activity of last Thursday, Sep. 20.)

What Kind of Binary Star System?

(a) What causes a particular binary star system to fall into one of these categories?

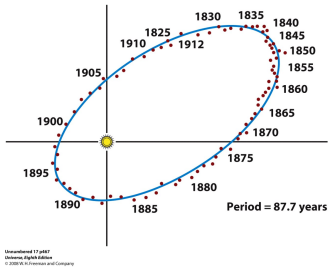
Some students thought the question was asking what causes a star to be in *any kind* of binary system, and said that it required having another star close enough for them to feel each other's gravity. In fact, the question was asking about what causes a particular binary system (given that we already know it's a binary) to belong to *one* of these categories, e.g. spectroscopic binary, as opposed to *a different* category, e.g. visual binary.

What Kind of Binary System?

The essential point is that **which** category you assign a particular binary system to *depends on your point of view as the observer,* as much as on the intrinsic properties of the system. (The hint was intended to remind you about our card exercise on intrinsic vs. relative properties.)

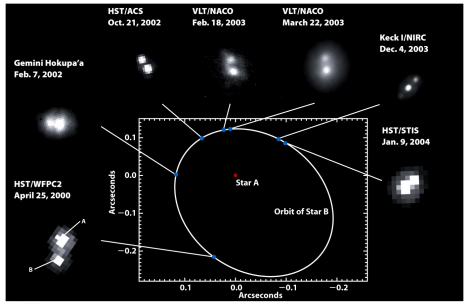
Some students got it, saying that what we see depends on our "vantage point," or "visibility." Others said it depends on the method of detection. This is not quite the same thing; it recognizes the role of the observer but leaves out the fact that certain conditions must hold in order to recognize that a binary system is present.

Visual or Astrometric Binaries



For a visual binary, you follow the positional changes of one or both stars over the orbit. For a large orbit like 70 Oph (left) this can take a *long* time!

Note: This gives you the orbit size in angular units (arc seconds); to get the physical size, you need distance (from parallax).

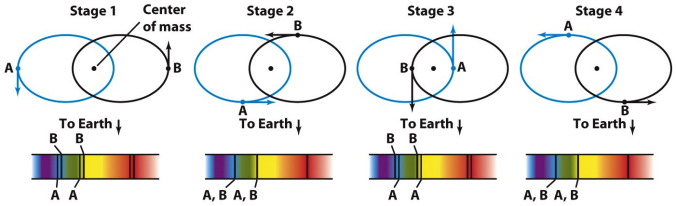


Conditions for Seeing a Visual Binary

- In order to see a visual binary system, we require that:

  - The physical separation of the stars has to be large enough to see the two stars separately, or at least to see one star move around a large orbit; or
  - The system has to be relatively close to you, so that a small physical distance corresponds to a measurable change in (angular) position on the sky; or
  - A special technique that can distinguish very small separations and/or shifts on the sky must be used, for example adaptive optics or interferometry.

Spectroscopic Binaries



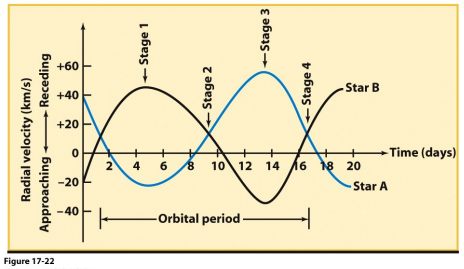


Figure 17-22
Universe, Eighth Edition

By taking a series of spectra, you can trace out a "radial velocity curve." The velocity times the period gives you the orbital size (e.g. for a circular orbit).

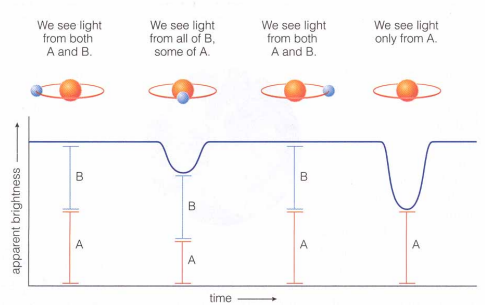
Seeing a Spectroscopic Binary

The way you recognize binarity through spectroscopy is by seeing a period Doppler shift in a star's spectrum, or possibly by just seeing two sets of spectral lines (but the latter could be due to an unrelated background star).

We see Doppler shifts only from the part of the motion directly towards or away from us, the *radial velocity*. In order to see any Doppler shift at all, the orbit must be oriented in such a way that *at least part of* the orbital motion is along our line of sight. If we are looking exactly "edge-on," the radial velocity will be equal to the actual orbital speed; if it is somewhat tilted, we see only a fraction (less than 100%) of the orbital speed.

Seeing an Eclipsing Binary

In this case the role of orientation of the orbit is even more obvious than for Doppler-detected binaries. You won't see eclipses unless you see the orbit very nearly edge-on, so that the stars pass in front of each other.



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(b) Can a given binary star belong to more than one of these categories? Explain.

Sure! The categories are not exclusive. The stars themselves don't know about these labels. Many of you pointed out that an eclipsing binary will also show Doppler shifts and therefore be a spectroscopic binary. The inverse is not necessarily true, because seeing eclipses requires very careful alignment, whereas we can see part of the orbital motion as Doppler shifts even for "intermediate" tilts. Even a purely edge-on orbit will cause "back-and-forth" (in a line) motions of the stars, but we might not see this unless the stars are nearby.

Errors and Misconceptions

- "What category a star system falls in is based on a star's intrinsic properties." This is the exact opposite of the truth: it depends on *both* intrinsic properties ***and*** the observer's perspective.
- "Visual and spectroscopic are mutually exclusive." This is incorrect. A system can be both, if the orbit has an edge-on or intermediate tilt relative to us. Only if the orbit is in the plane of the sky can it be a visual binary without showing any Doppler shift.
- "An eclipsing binary is a change in the brightness of a star to find the parallax of the system." This is garbled. Parallax is not relevant here.

Overly Vague Responses

- "The stars have different properties which allow them to be seen in certain ways." This is extremely vague, and would not earn credit on a quiz or exam.
- "The properties of the stars in the binary system determine which category they fall in." This is both too vague, and incorrect. The main point of the query is that classification as a type of binary system is *relative* to the observer, **not** wholly intrinsic.
- "A binary system falls into any one of these categories by how it interacts or orbits around the other stars." This also misses the main point.