The Motions of the Stars

The “Fixed” Stars

To the naked eye, the stars appear “fixed” to the sky.

In reality, the stars are in constant motion.

Great distances make the amount of motion small on a human lifetime.

Radial Velocities

Radial Velocity

Motion along the line of sight.

Measure using the Doppler Shift of the star’s spectrum:

- Moving towards Earth: Blueshift
- Moving away from Earth: Redshift
- Moving across line of sight: No Shift

Proper Motions

Angular motion across the sky of nearby stars with respect to distant stars.

- Typical proper motion: ~0.1 arcsec/year.
- Largest: 10.25 arcsec/yr (Barnard’s Star).

Reflects true motion of the stars through space
Discovery of Proper Motions

Edmund Halley (1718):
Noticed that the positions of 3 bright stars, Sirius, Aldebaran, & Arcturus had moved by about 20 arcminutes from the positions given by Hipparchus of Rhodes in 300BC.

Proper motions are *cumulative*

Effects build up over time:
- The *longer* you wait, the *greater* the angular motion is.

Measuring proper motions:
- Compare photos of the sky taken at two separate times
- Measure how much stars have moved.

Example

Star with a proper motion of 0.1 arcsec/year:
- After 1 year: it moves 0.1 arcsec
- After 10 years, it moves $10 \times 0.1 = 1$ arcsec
- After 100 years, it moves $100 \times 0.1 = 10$ arcsec

It takes many millennia for the constellations to noticeably change shape.

Case Study: The Big Dipper

Today

50,000 BC

More *distant* stars tend to have *smaller* Proper Motions for same transverse velocity:

Can usually measure accurate proper motions out to distances of ~1000 parsecs.
**Space Motions**

Want to know the true motion of a star through space.

- **Observed motions:**
  - proper motions: angular motion
  - Transverse or tangential velocity: need to know the Distance and Proper Motion
  - radial velocity: motion along line-of-sight

**True space motion**
- Combine Transverse & Radial Motions

**Why measure space motions?**

Most useful when measured for many stars. Use statistics of the motions to find:
- Motion of the Sun through nearby space (towards the constellation of Hercules)
- Local rotation of the Milky Way galaxy

Important tool for studying the structure of the Milky Way galaxy.

**Parallax or Proper Motion**

1. If observed at the same time of the year, every year, parallax is zero but proper motion would be visible.
2. Parallax is only along the direction of earth’s motion. Star’s movement in other directions would imply proper motion.
3. Parallax has to go back and forth—but proper motion is cumulative, i.e. the effect builds up with time.

**To measure a star’s tangential velocity, we need to measure its:**

- A) Proper motion and parallax
- B) Proper motion and radial velocity
- C) Doppler shift and spectral type
- D) Parallax and radial velocity

**A spectrum of a star gives no information on the star’s**

- A) Radial velocity
- B) Tangential velocity
- C) Composition
- D) Luminosity
- E) Temperature