

Topic E

Part 2. "Stellar Motions"

(Web Version: 03-23-01)

1

Proper Motions of Stars


(Apparent Motions of Stars)

2

"Fixed Stars"

- Till now assumed stars on sky
 - Fixed (relative to each other)
 - So star patterns don't change
- Questions:

• Do stars move through space relative to Sun?	Yes
• If yes — effect observable?	Yes
• If yes — do motions influence parallax?	Yes



3

Want to Contrast

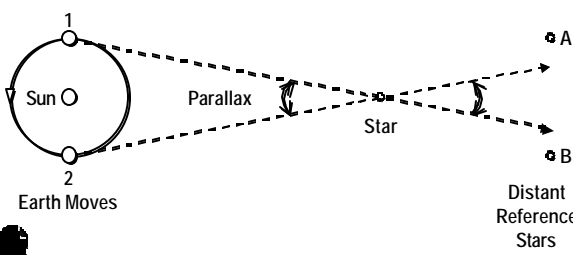
- Stellar Parallax:
 - From Earth's annual *orbital motion* about Sun
- Proper Motion:
 - From star's motion in space (relative to Sun)

"Both cause positions of stars on sky to change over time"

4

Annual Parallax

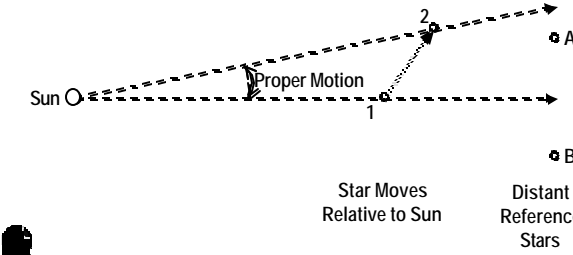
Due to Earth's Orbital Motion



5

Proper Motion

Shift due to star's motion relative to Sun



6

From Earth See Combination

Sun O

Earth Moves **and** Star Moves Relative to Sun

Combined Shift

Distant Reference Stars A B

7

Measuring Proper Motion

- Should appear as "drift" of star across sky
- Measure by comparing sky photos taken many years apart
- Has any star moved? (If so . . . which one?)

1945

1995

8

Proper Motion is "Drift"

- Suppose . . . Measured drift = 5 arc sec
- What is elapsed time? Answer: 1995 - 1945 = 50 years
- What is the proper motion? Answer: $5''/50 \text{ yrs} = 0.10''/\text{yr}$

1945

1995

9

Angular Drift

- Proper motion is *angular drift*
- Unit is *angle / time* (e.g., $0.10''/\text{yr}$)
- Since very small usually *arc sec per year* (or *''/yr*)
- Recall parallax . . .
 - Only an angle* (arc sec)
 - Not drift* but periodic (annual) shift

1945

1995

10

Some Results

Largest proper motion . . .

Barnard's Star: p.m. = $10.4''/\text{yr}$!

Also second closest star to Sun (if count Alpha Centauri system as one star)

- $p = 0.54''$ (what is d in pc?)
- $d = 1.9 \text{ pc}$ (what is d in ly?) = 6 ly

11

How Fast is $10.4''/\text{yr}$?

How long to move apparent width of Moon?

- Answer: $1800'' \div 10.4''/\text{yr}$ or about 173 years (only about two human life times!)
- Star not* noticeable to naked eye (mag. = +9.6 requires binoculars or telescope)

1800''

Moon

12

More Proper Motion Results*

Star	Proper Motion
Alpha Centauri	3.7"/yr
Sirius	1.3"/yr
About 400 stars have	More than 1"/yr
Naked eye stars	Less than 0.1"/yr (typical)
Betelgeuse	0.03"/yr
Polaris	0.007"/yr

* See Study Guide Table 9

Proper Motion

Most proper motions very small but

- Can influence parallax measurements (because parallax also small)
- Unlike parallax . . . proper motion measurements aided by waiting!

Time and Proper Motion

Constellation patterns

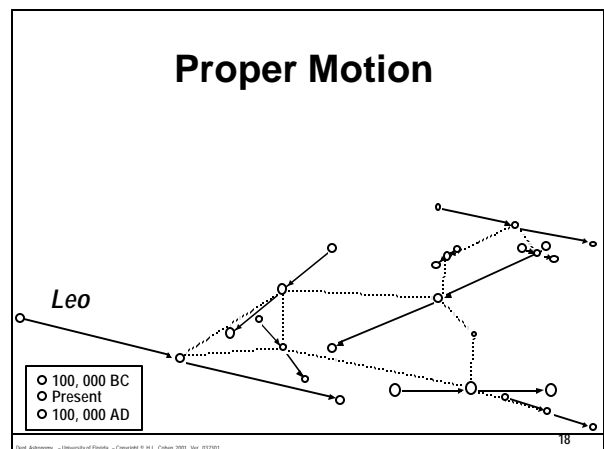
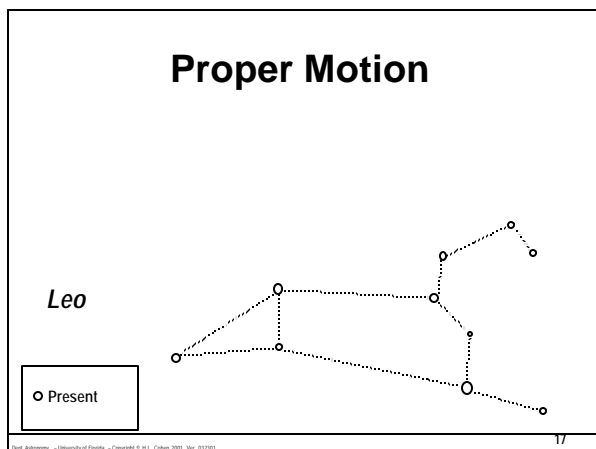
- Essentially unchanged over human generations but . . .
- will change over tens of thousands of years*
- Example follows

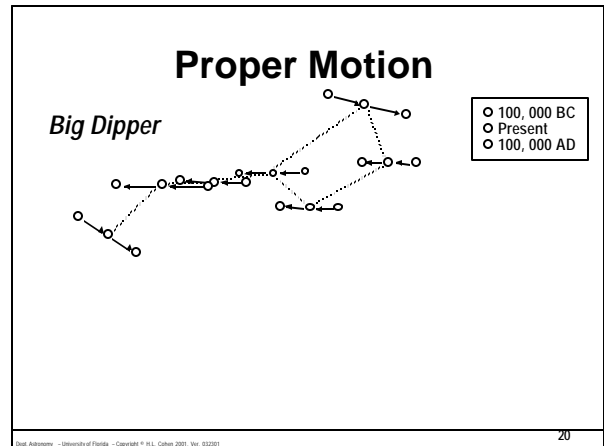
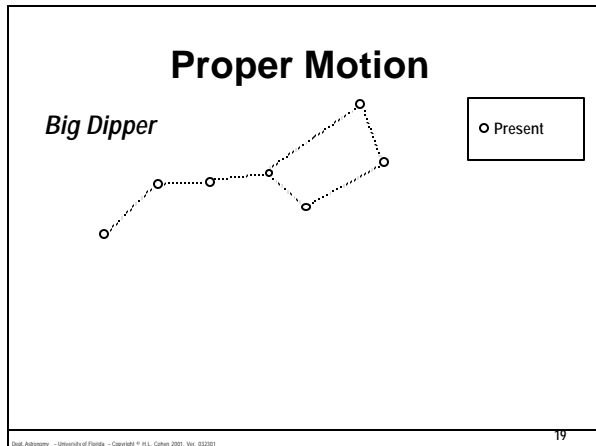
Example Star Groups

Will compare two regions of sky:

- Big Dipper* (an "asterism")
- Leo* ("The Lion")

Watch proper motions over 200,000 years
(100,000 BC to 100,000 AD)



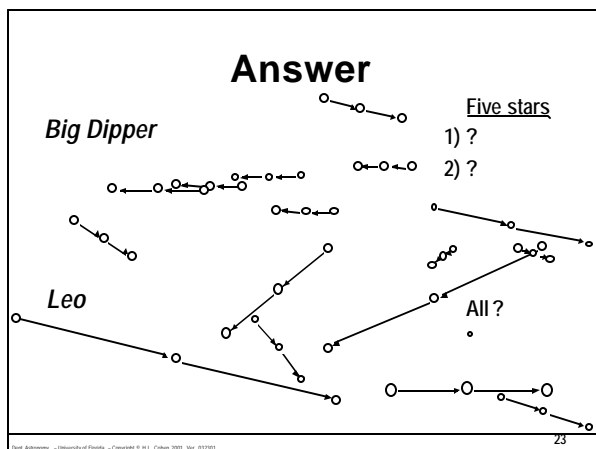
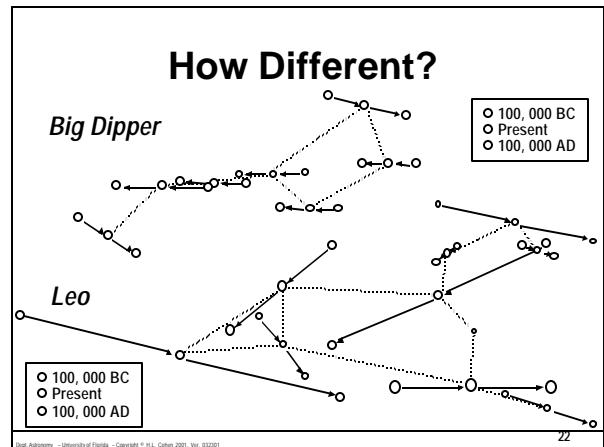


Proper Motions Differ

- Proper Motions in Leo & Big Dipper Differ
(Two major differences)
- Do you see how?
 - Difference #1?
 - Difference #2?

Look again

21



Ursa Major Region

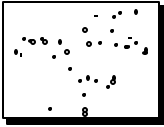
- Many stars in this region have “common proper motions”
 - Values – similar
 - Directions – similar
- Conclusion —
 Stars move along *parallel paths* . . .
 Belong to a “swarm”
 . . . a *star cluster*

24

Recognizing the U Ma Cluster

Proper motions make U Ma cluster's existence known!

- Look like a cluster?
- *Too close* to be recognized (Distance to center 25 pc)



This looks like a cluster (NGC 3293)

- Cluster far (2500 pc!)
- Cluster stars stand out from other stars

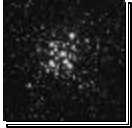


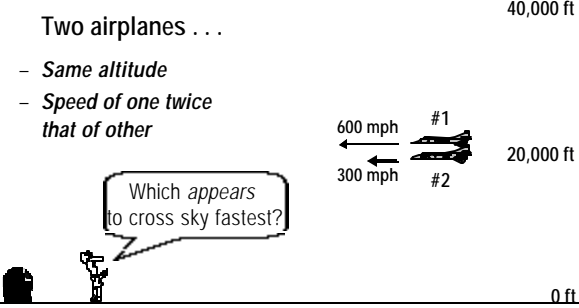
Photo cred. Anglo-Australian Observatory

25

Factors Influencing P.M.

Two airplanes . . .

- Same altitude
- Speed of one twice that of other



40,000 ft

20,000 ft

0 ft

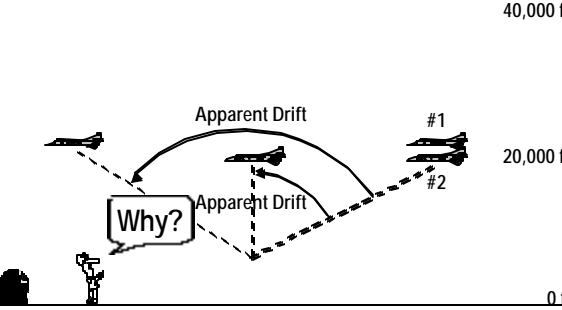
600 mph #1

300 mph #2

Which appears to cross sky fastest?

26

Drift of #1 Larger



40,000 ft

20,000 ft

0 ft

Apparent Drift

Apparent Drift

Why?

#1

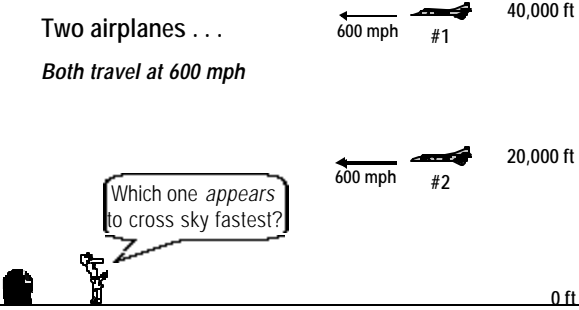
#2

27

Another Factor

Two airplanes . . .

Both travel at 600 mph



40,000 ft

20,000 ft

0 ft

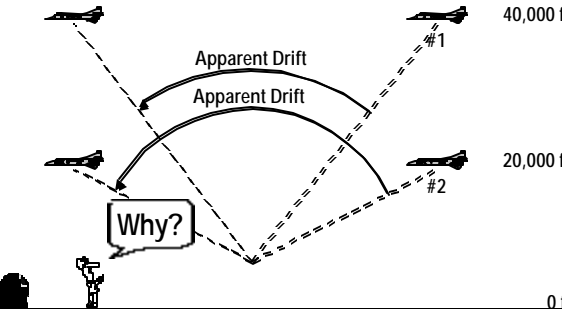
600 mph #1

600 mph #2

Which one appears to cross sky fastest?

28

Drift of #2 Larger



40,000 ft

20,000 ft

0 ft

Apparent Drift

Apparent Drift

Why?

#1

#2

29

Proper Motion Depends On

- 1) Speed (fairly obvious)
- 2) Distance

- Which most "important" (has greatest effect)? Answer . . . ?
- Why? Answer . . . ?

30

A Distance Guide

Rule “not caste in stone” but . . .

- Large proper motion, probably close,
- Small proper motion, probably far.

Use:

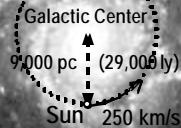
Helps select potential stars close enough for detailed parallax measurements

Brief Catalog of Star Data

- See *Study Guide* Table 9
- Data for 16 stars
Includes Sun, 12 bright and 3 faint look stars
- Pertinent columns
 - Col. 1-2 Name & Apparent Magnitude
 - 5 Parallax
 - 6-7 Distance (pc & ly)
 - 8 Proper Motion

Our Milky Way Galaxy

Sun's Galactic Period = 250 million years



(Value approximate)