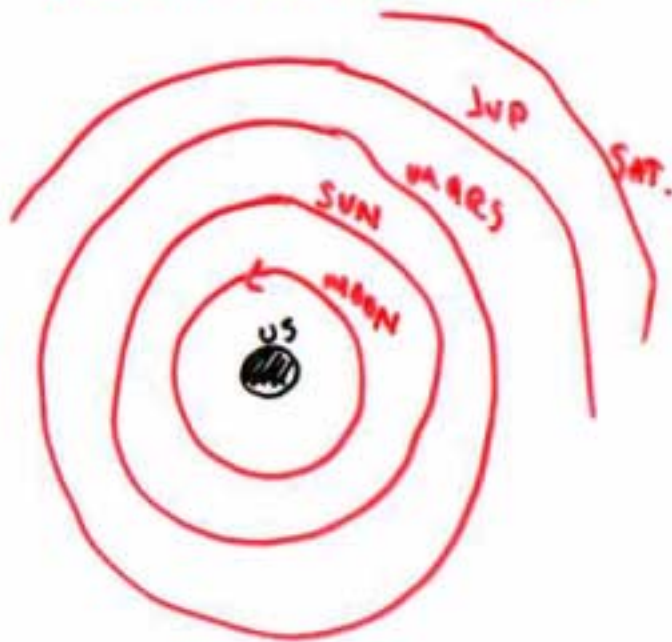


□ EVOLUTION OF DESCRIPTIVE MODELS.

6-3

PTOLOMEY

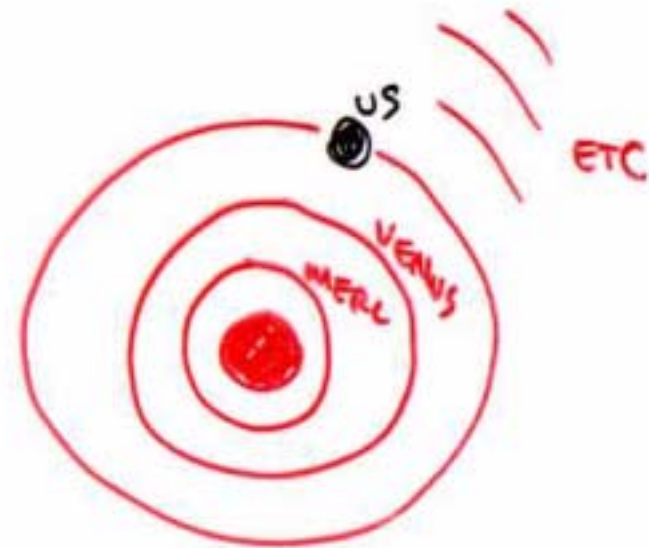
ASSUME: ALL IN HEAVENS IS CIRCULAR
EARTH IS AT CENTER



CALCULATIONS FOR PLANET POSITIONS GOOD WITHIN 1° AFTER 2,000 YEARS

COPERNICUS

ASSUME: ALL IS CIRCULAR
BUT THE SUN IS AT CENTER



CLUMSY, HARD TO CALCULATE, DIDN'T WORK AS WELL...

DEPARTURE FROM "THINKING"
NEED OBSERVING - TYCHO BRAHE

BRAHE + KEPLER

NEITHER PTOLOMEY

"EARTH"-CENTERED

NOR COPERNICUS

"SUN"-CENTERED

WORKS EXACTLY.

GOOD, LONG-TIME, PRECISE CAREFUL MEASUREMENTS.

GOOD MEASUREMENTS

IF WE'RE GOING TO ARGUE, IT WOULD BE
BEST TO FIND OUT WHAT IS ACTUALLY GOING ON.

EMPIRICAL LAWS,
REGULARITIES
IN THE DATA

KEPLER - WORKED HARD TO MATCH A THEORY
TO BRAHE'S DATA.

ASSUMPTION:
CIRCULAR MOTION
IN HEAVENS

CALCULATE PTOLOMEY

/// NEITHER WORKED OUT

CALCULATE COPERNICUS

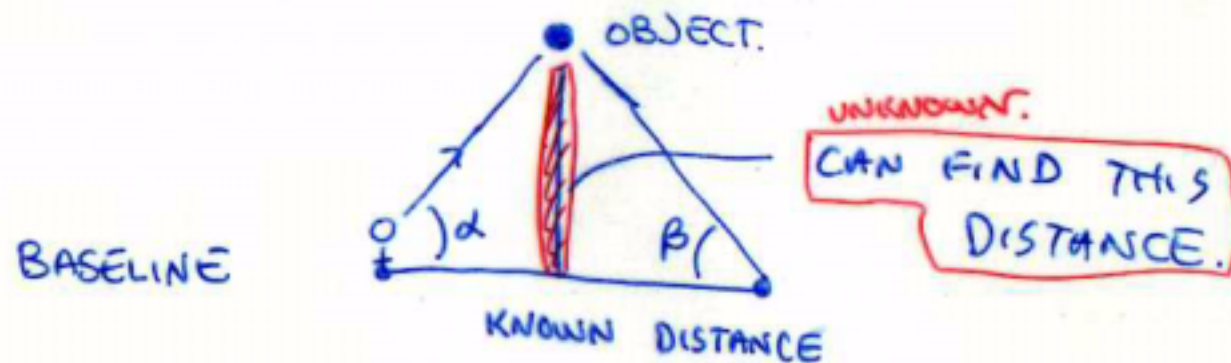
□ QUESTION THE ASSUMPTION

6-14

DO OBJECTS IN THE HEAVENS GO IN CIRCLES?
UNIFORM MOTION?

HOW DO THINGS REALLY MOVE?

TRIANGULATION IS A GOOD POSITION-FIXING TOOL.

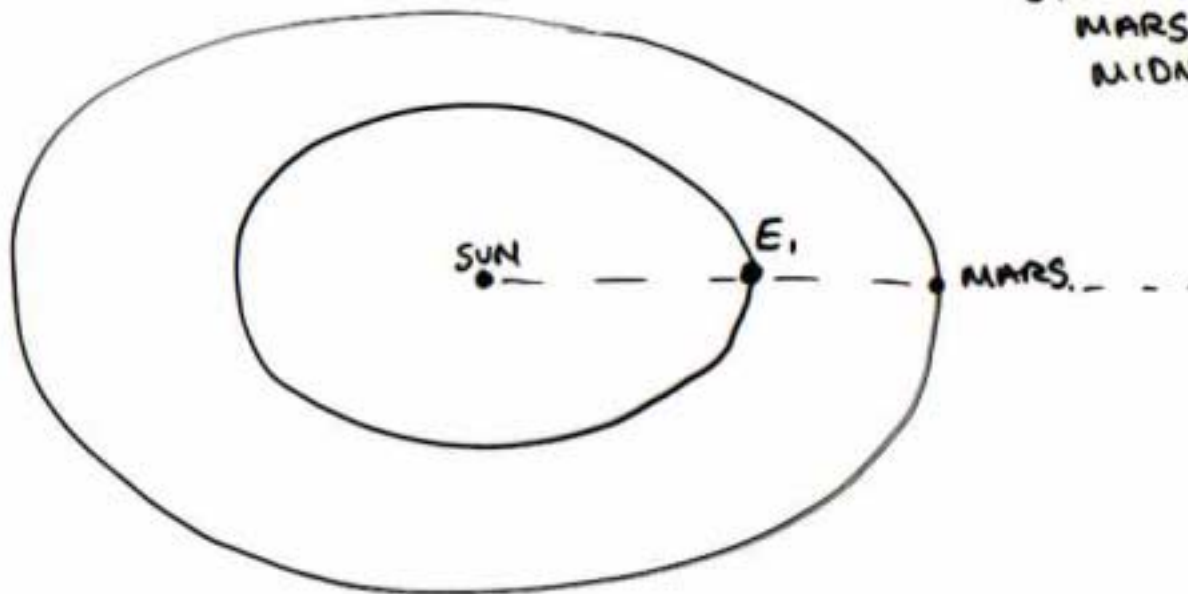


□ EARTH MOVES... MARS MOVES...
HOW TO TRIANGULATE?

6-16
6-17

MARS YEAR = 687 DAYS. EVERY 687 DAYS
RETURNS TO EXACTLY SAME SPOT IN THE
SOLAR SYSTEM.

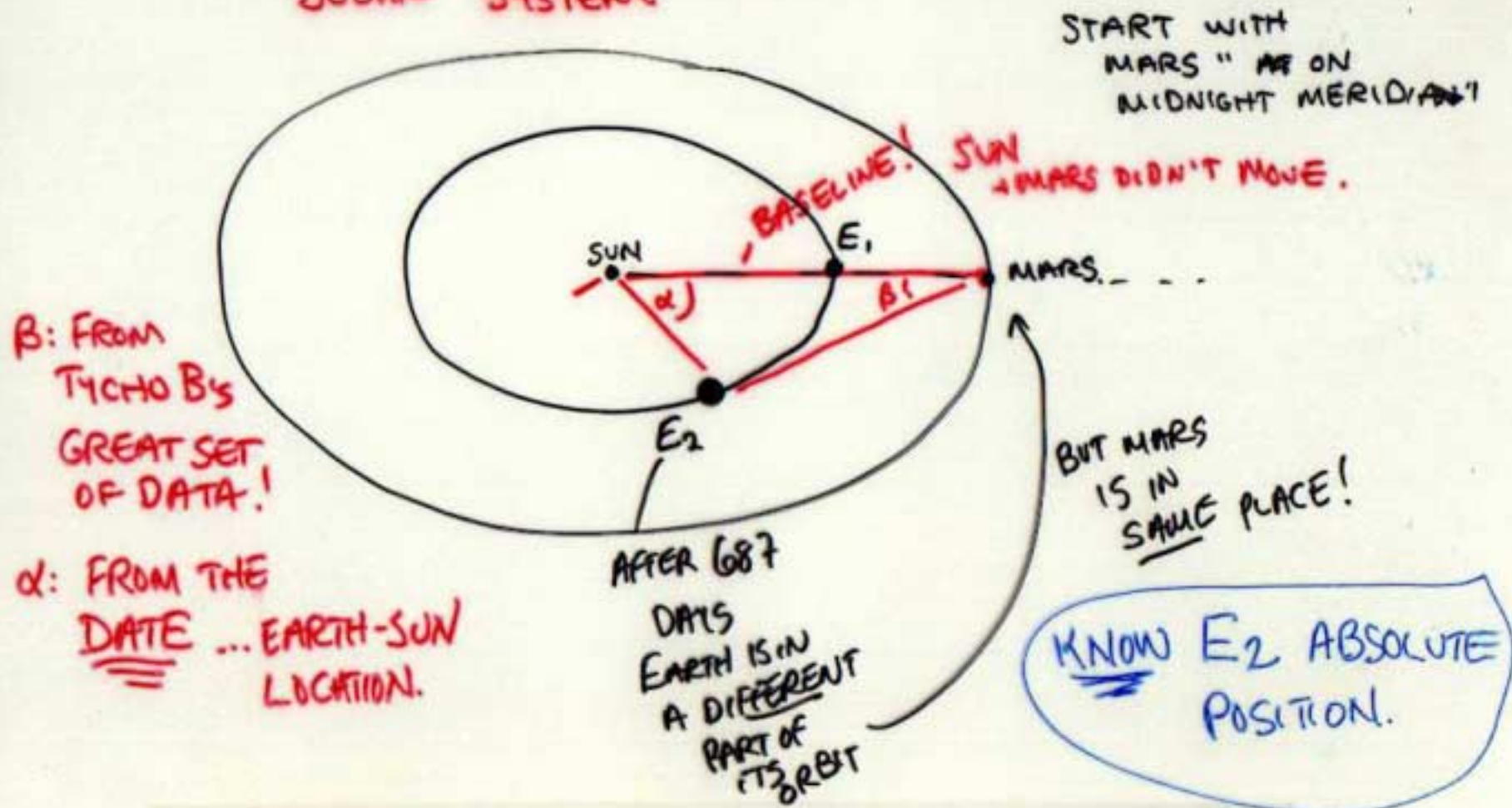
START WITH
MARS "AT ON
MIDNIGHT MERIDIAN"



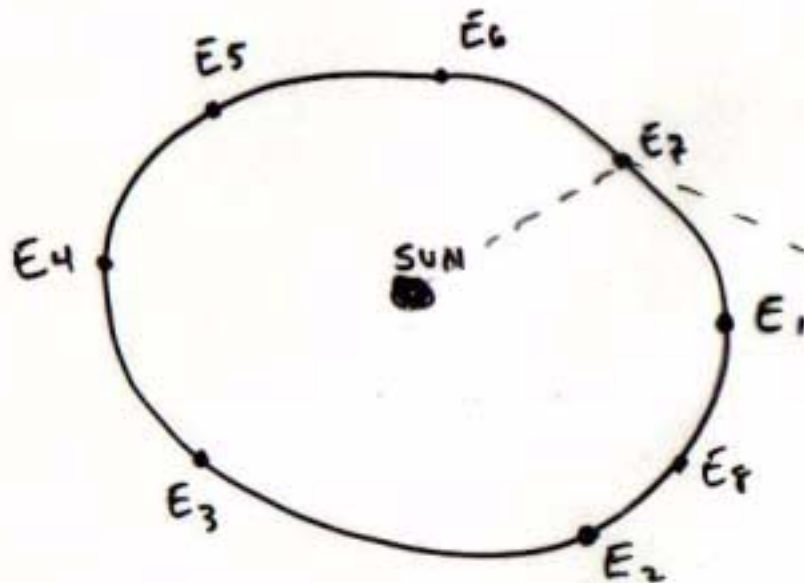
□ EARTH MOVES... MARS MOVES...
HOW TO TRIANGULATE?

6-16
6-17

MARS YEAR = 687 DAYS. EVERY 687 DAYS
RETURNS TO EXACTLY SAME SPOT IN THE
SOLAR SYSTEM.



KEPLER HAD 20 YEARS OF DATA. (FROM TYCHO BRAHHE!)



HE DIDN'T HAVE TO
"GUESS" THE SHAPE
OF THE EARTH'S ORBIT.

HE HAD MEASURED IT.

→ MARS!

AND THEN, WHEN WE
KNOW HOW WE ARE
MOVING — HOW DO
OTHER PLANETS MOVE?

KEPLER'S "EMPIRICAL" LAWS

EMPIRICAL!
NO THEORETICAL
OR DEEP
UNDERSTANDING
— YET!

1. ORBITS ARE NOT CIRCLES — ELLIPSES

THE SUN AT ONE "FOCUS"

2. ORBIT SPEEDS UP NEAR THE SUN

3. $(\text{TIME OF CYCLE})^2 / (\text{DISTANCE OF ORBIT})^3 = \text{CONSTANT!}$

□ WHERE ARE WE (IN THE COURSE)

● PATTERNS + MOTION IN THE SKY

CH 1-5

- COMPLICATED
- EVERYTHING MOVES
- SUN + SEASONS, MOON + ECLIPSES

CH 6

- WITH KEPLER **QUANTITATIVE** RECORD OF MOTION, MARS, EARTH



BUT NO DEPTH OF UNDERSTANDING!

WHY ARE KEPLER'S LAWS TRUE?

CH 7, 8, 9
ETC.

UNDERSTANDING **K**'S + PLANETS STARTS WITH UNDERSTANDING MOTION - HERE -

ONE SET OF LAWS FOR ALL OF THIS.

HOT WHEELS CARS ON TRACKS

PENDULUMS SWINGING

JUPITER

BLACK HOLES

CARS

□ START WITH GOOD DEFINITIONS FOR MOTION

- CAN'T JUST JUMP IN AND EXPLAIN KEPLER'S LAWS.
- MOTION ON TABLE TOP IS THE SAME AS MOTION IN THE SKY
- NEED TO GET THINGS STRAIGHT RIGHT HERE BEFORE ANYTHING ELSE.

EVERY CAR ON A TRACK, BOUNCING BALL, SWINGING PENDULUM, SHAKING SLINKY HERE EXPLAINS SOMETHING OUT THERE.