Length of the Seasons
Mars in Retrograde
Planetary Alignments

Dr. Scott Schneider

Tuesday Feb 21st, 2006

As part of the Arts and Sciences Seminar Series

Webpage :

http://qbx6.ltu.edu/s_schneider/astro/astroweek_2006.shtml

Cast your minds back …

- The year is 1563 .. The Month August .. The observer … Tycho Brahe
- “Conjunction” of Saturn and Jupiter (close together in the sky)
- Off by several days/months depending on the astronomy table chosen
- Seen by Tycho near Aug 16th 1563 ….

Let’s use modern software …

- Using software that comes with our Astronomy textbook – quite accurate
- Dial the “way back” machine to 1563 to see this “alignment”
- And, we can confirm the date (important historical research coming up!) ….

Skygazer Demo!

Oops Aug 25th?… off by 10 days?

- Trust me that the software is good …
- I'm not "cheating the date on the screen" …
- 10 days …. 10 days …
- 1563 …. 1563 …..
- Dr. Scott puzzled and puzzed, until his puzzler was sore!

The light dawns …
{The sun comes up, the day awakes!}

- And then he thought of something that he hadn't before …
- **Pope Gregory XIII !!**
- The Gregorian Reformation!
- 10 Day shift in the calendar occurred in 1582 !! (Aug 15th 1563 Julian = Aug 25th 1563 Gregorian!)
- Leap day requirement known since Julius Caesar .. Starting to drift by 1582 (Easter/Spring dates)

So, new formulas needed …

- Julian … only add leap day every 4 years
  - By 1500's, Calendar was beginning to slip
  - 365.24219 days in tropical year
  - Every four years gives 365.25 (too much)
- Gregorian – added rules for 100/400 years
  - If year divisible by 100 – not a leap year
  - But, if year is divisible by 400 – yes!
  - 365 + 1/4 - 1/100 +1/400 = 365.2425
    - May need a new rule at 3600 or 4000
- But, all that makes it better, right? Nope!

1) Lengths of the Seasons

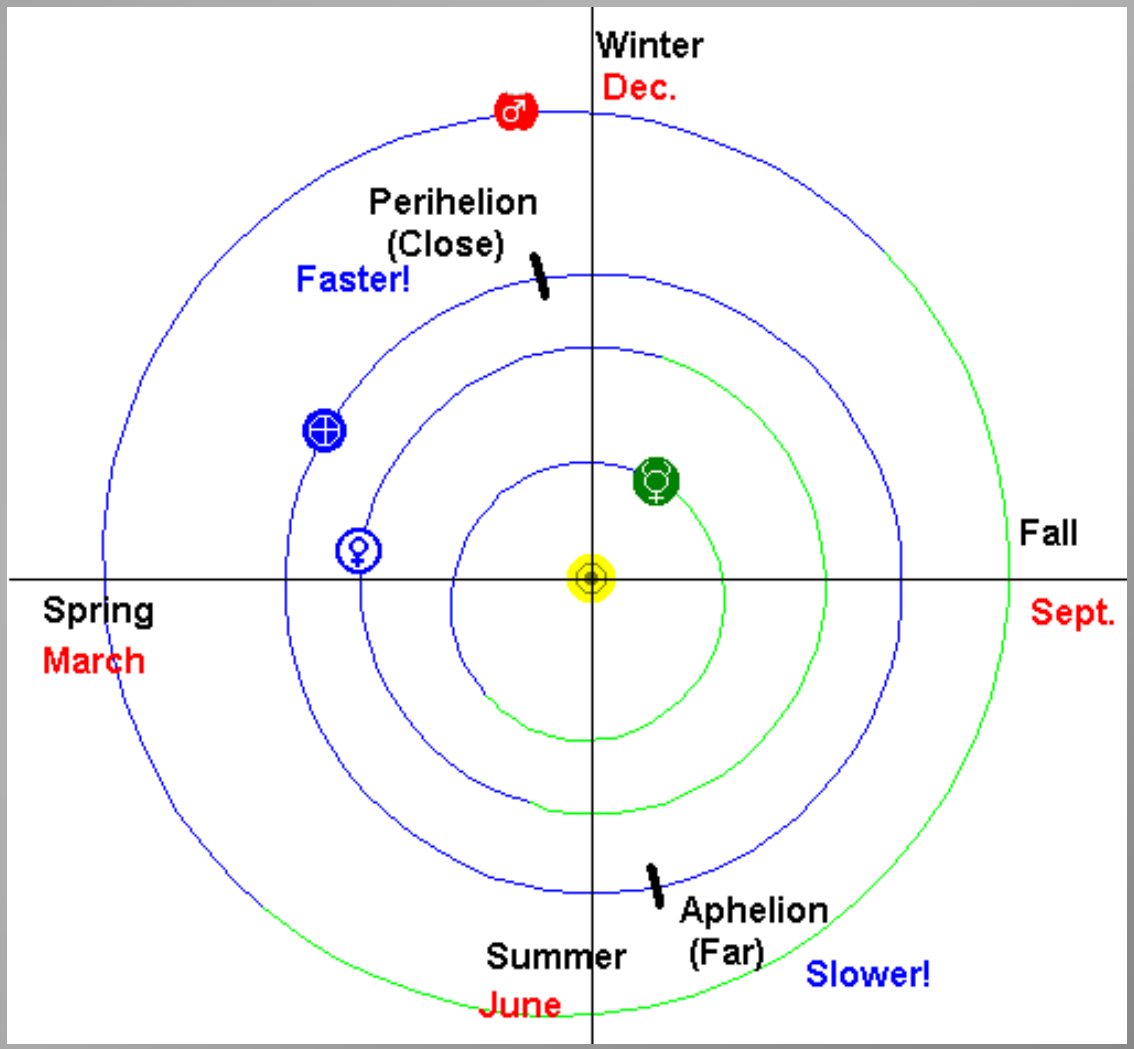
- **Even though leap days help – lengths of seasons will still change, over long time**
- **Earth orbit is "drifting" around the Sun**
  - **Precession (rotation) of the orbit**
    - **Caused by pull from planets and Moon**
  - **Close/Far points in orbit move (season "makers" do not move!)**
- **But *duration* of seasons oscillate over time**
  - **Near 2000, Spring = 92.76 days, Summer = 93.65 days**
  - **By 3000, Spring drops to 91.97, Summer rises to 93.92**

Finding your way in the Solar system :

- **All planets go around the Sun**
  - **also, in the same “direction”**
- **Define reference plane as Earth-Sun**
  - **Called the ECLIPTIC**
  - **All other planet orbits tilted, relatively**
- **Venus/Mars have orbit tilts relative to Earth Sun plane**
  - Save this info for later!
- **Earth sometimes closer, sometimes farther**
  - Aphelion = far (actually occurs in Summer!) – Earth moves slower
  - Perihelion = close (occurs in January) – Earth moves faster (Kepler!)

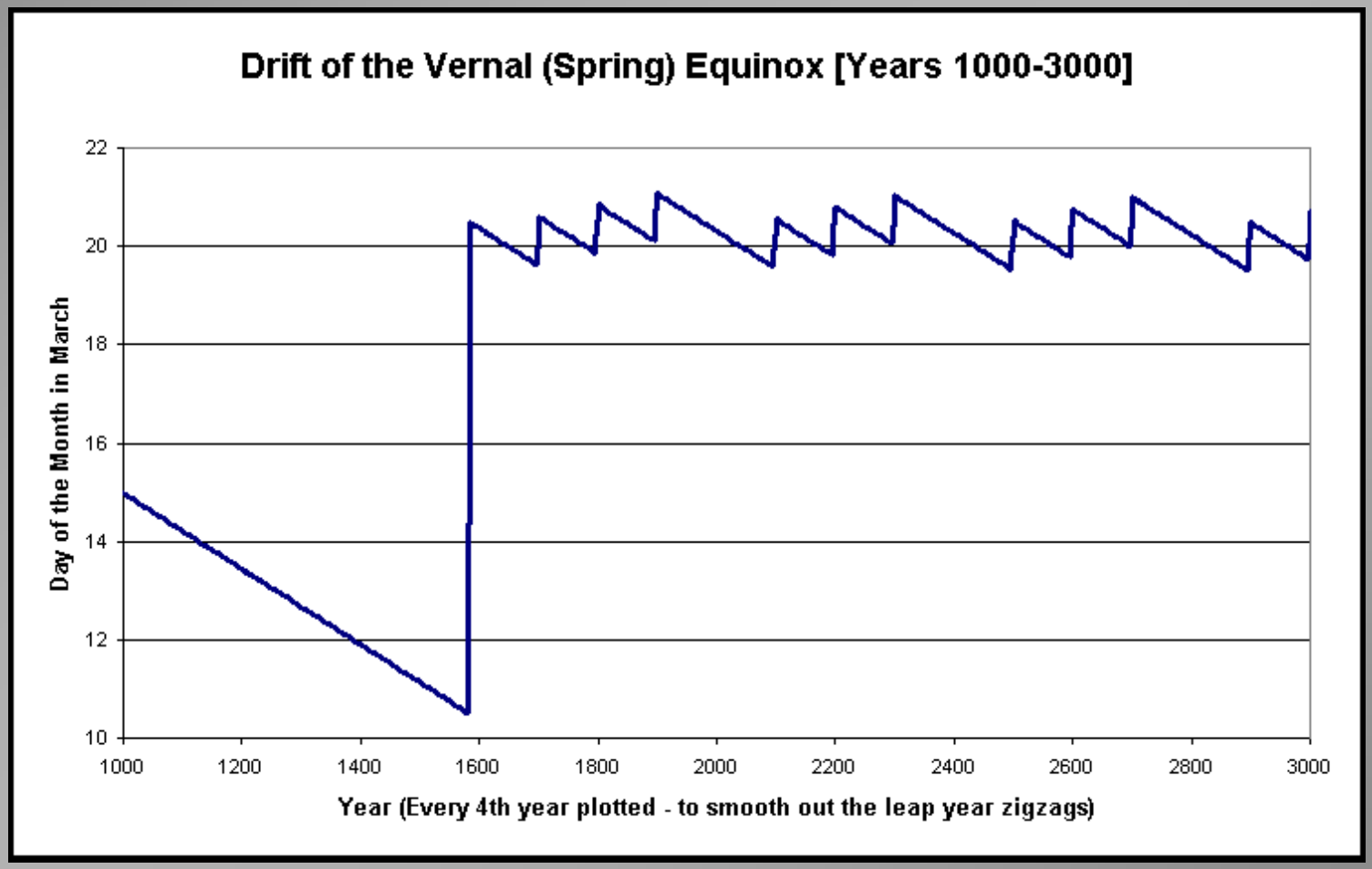
Seasons vs. Aphelion/Perihelion

- **Spring defines quadrants**
- **2006 – March 20th – June 21st – Sept 23rd – Dec 22nd**
- **Quadrants near Aphelion are longer in Earth travel time around the Sun**
- **Perihelion and Aphelion drift (precess) – so season lengths change**



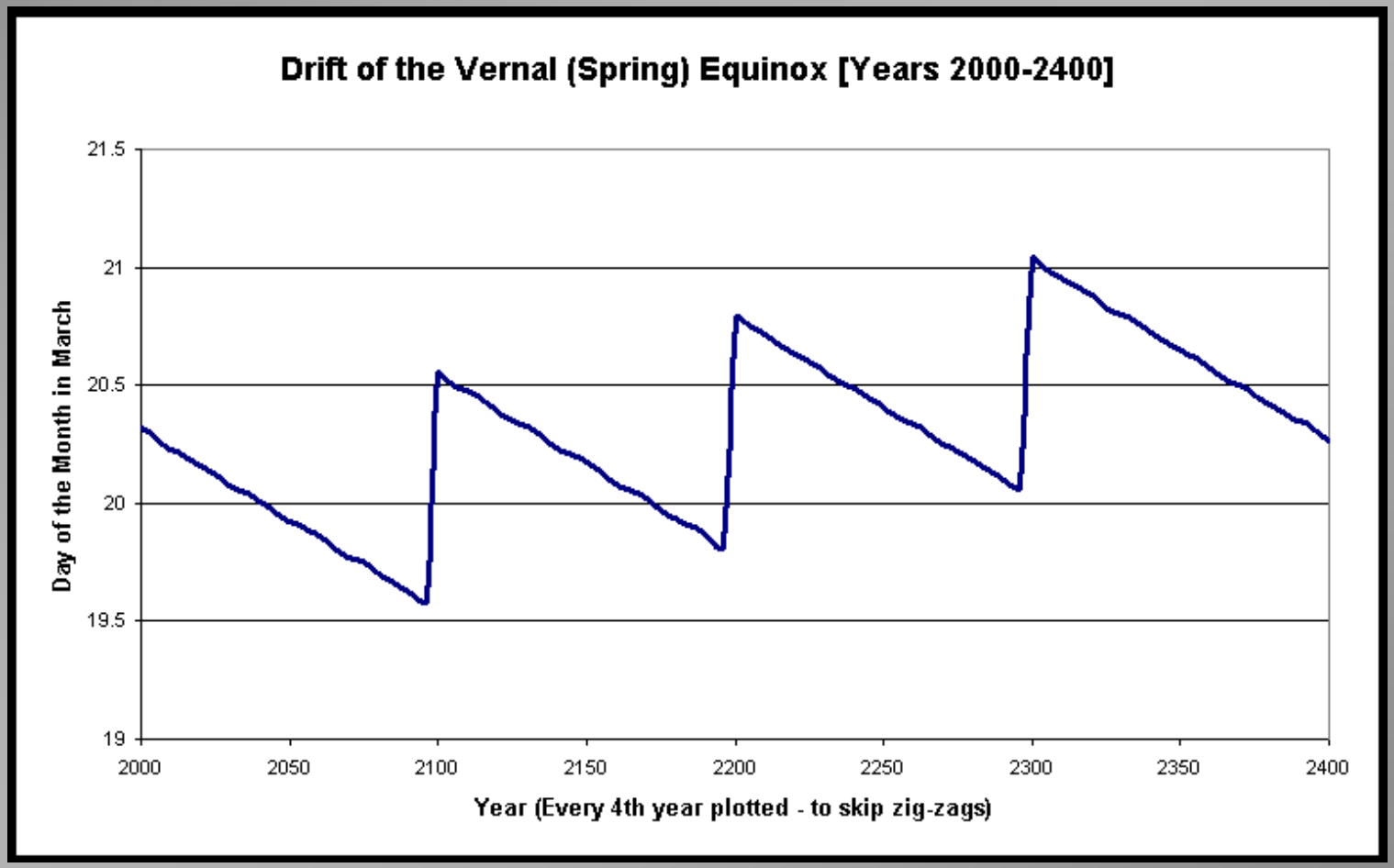
Follow Spring Equinox Date (wide)

- **Spike around 1600? – Gregorian Reformation!**



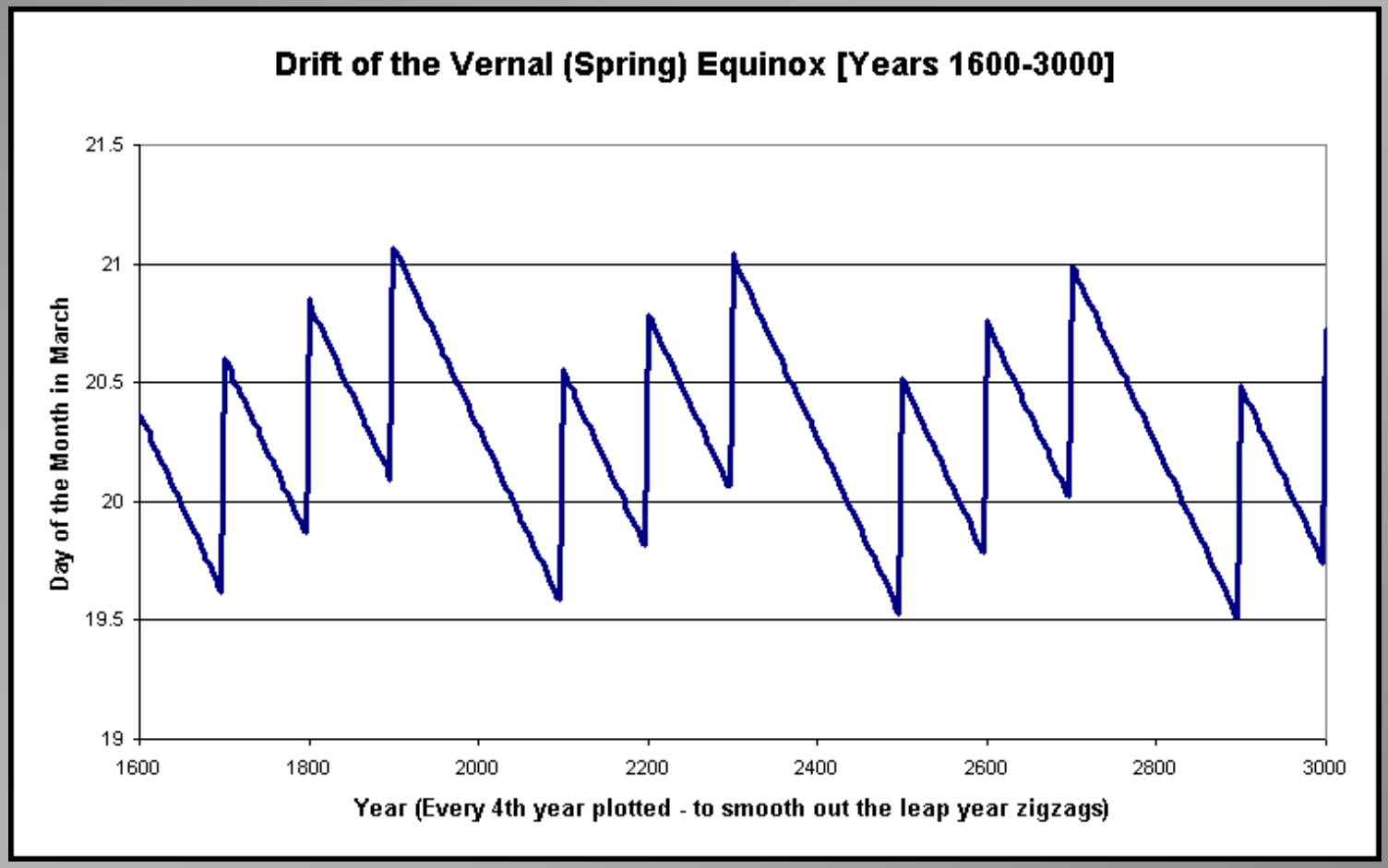
Follow Spring Equinox Date (zoom)

- **Slow drifting of the date later in March**



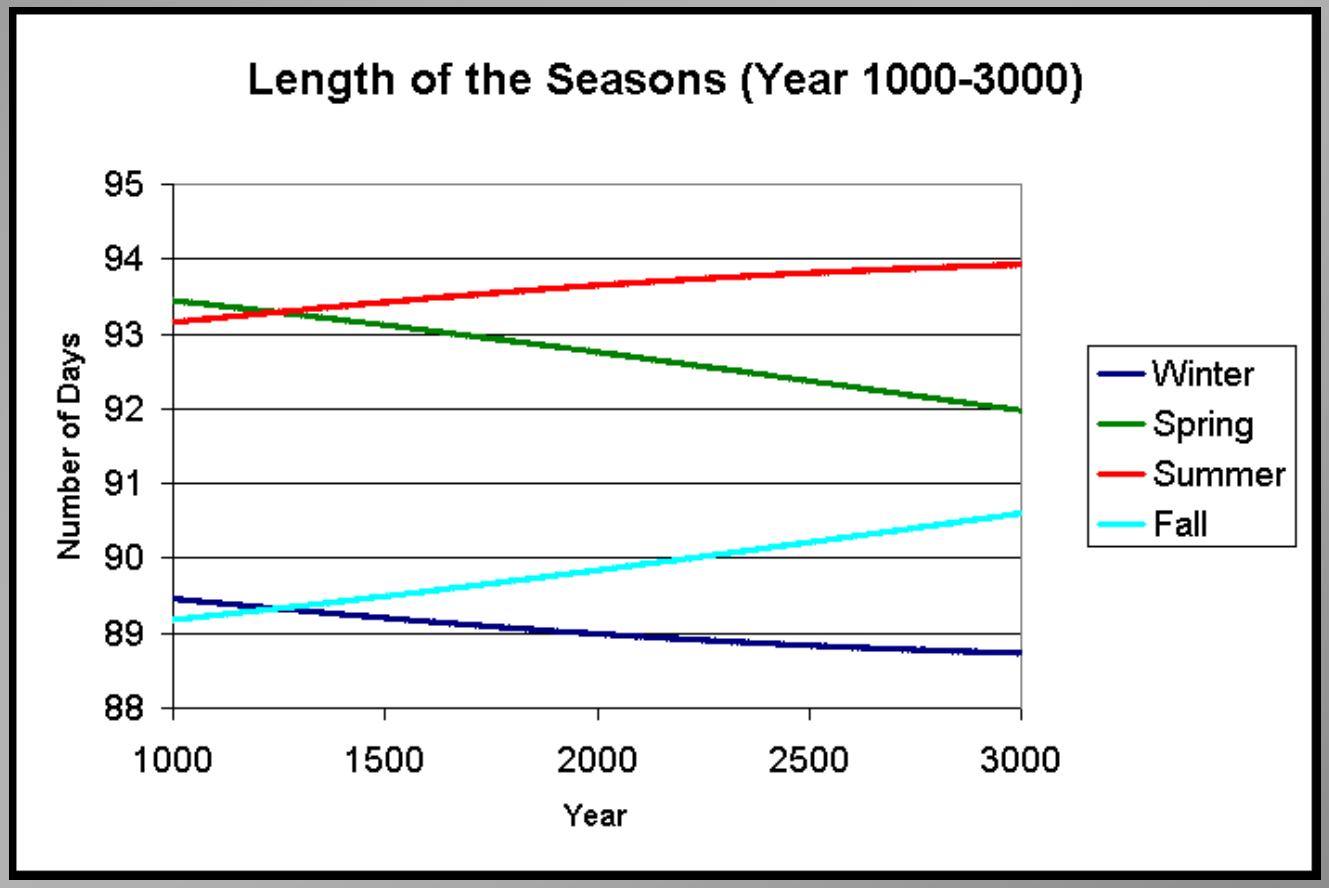
Follow Spring Equinox Date (med)

- **Small shifts at 100, none at 2000, 2400, 2800??**



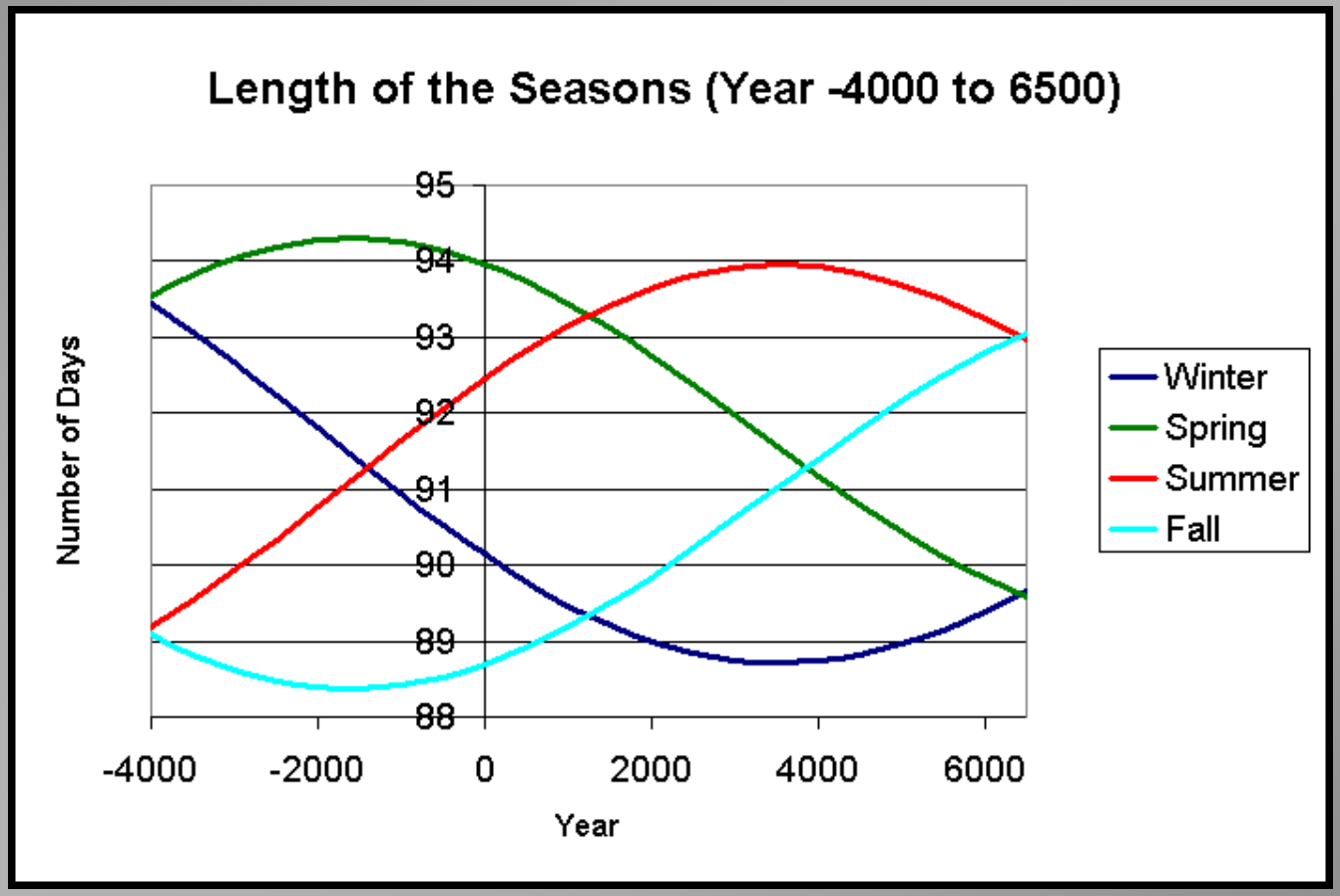
Season duration – short time scale

- **Currently Spring/Summer are longer**
  - **But, Spring duration shrinking .. Fall rising!**



Season duration – long time scale

- **Winter longest before – 4000 (shortest ~3500)**



2) Mars in Retrograde

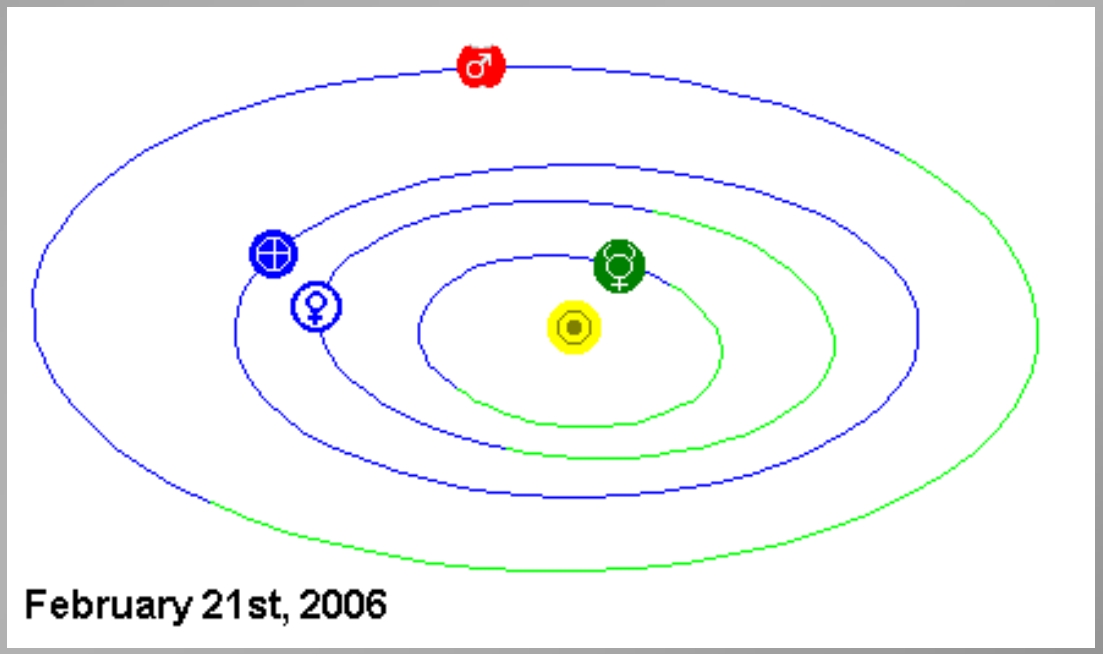
- This stumped “the ancients” – planets moving “backward” in their orbits?
- Added more “perfect circles” to their existing orbit circles *(sheesh, the circles!)*
- Never got it right until …
  - Put SUN at the center!
  - Get rid of circles on top of circles
  - Get rid of circles in general (ellipses rule!)

Ecliptic plane - Today

- **Oriented by Seasons (Spring/Fall line = pivot)**
- **Venus/Mars orbits = Blue = above … Green = below (nodes)**
  - **Remember that toward the end of the talk!!**

WINTER

SPRING

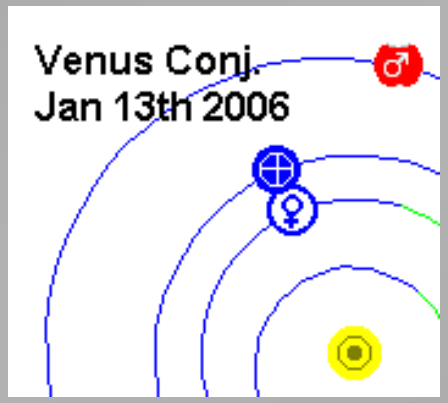


FALL

SUMMER

Conjunction junction … function?

- **Conjunction** – objects "together" in the sky
  - Tycho's Jupiter/Saturn – and later .. **Marvin the Martian!**
  - With inner planets – *transits* possible!
- **Opposition** – objects "opposite" each other in the sky
  - retrograde motion occurs during oppositions
  - Note: Mars oppositions occur at different "places" (about 780 {remember this!} days apart – 2 yrs, 50 days)



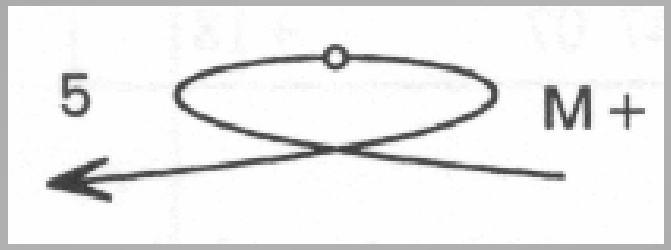
Skygazer Demo!

Shape of the retrograde loops?

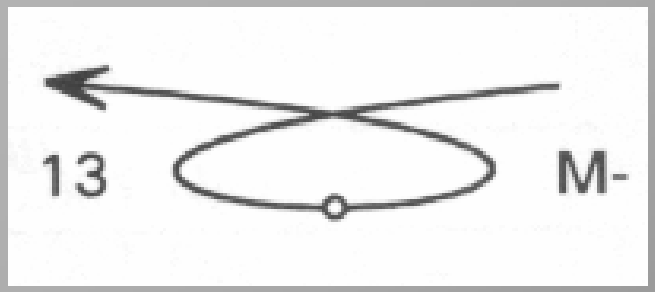
- The outer planets have orbits tilted relative to the ecliptic.
- Earth moves faster in orbit than outer planet.
- As Earth moves past opposition point, angle between Earth and outer planet changes orientation in space .. points to different background stars!
- During time of opposition, outer planet might change angle above/below ecliptic (latitude).
  - Also, Ascending Node or Descending Node ?

High or Low above ecliptic

As outer planet moves toward highest point in the motion, retrograde motion give “top loop” shape.



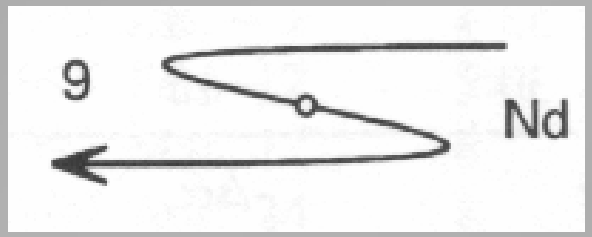
180 degrees away, as outer planet moves toward lowest point in it’s motion, retrograde motion give “bottom loop” shape.



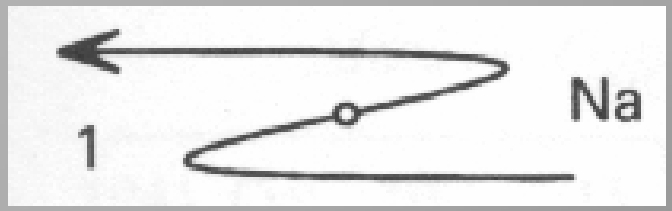
The “dots” are the moment of opposition.

Crossing above/below ecliptic

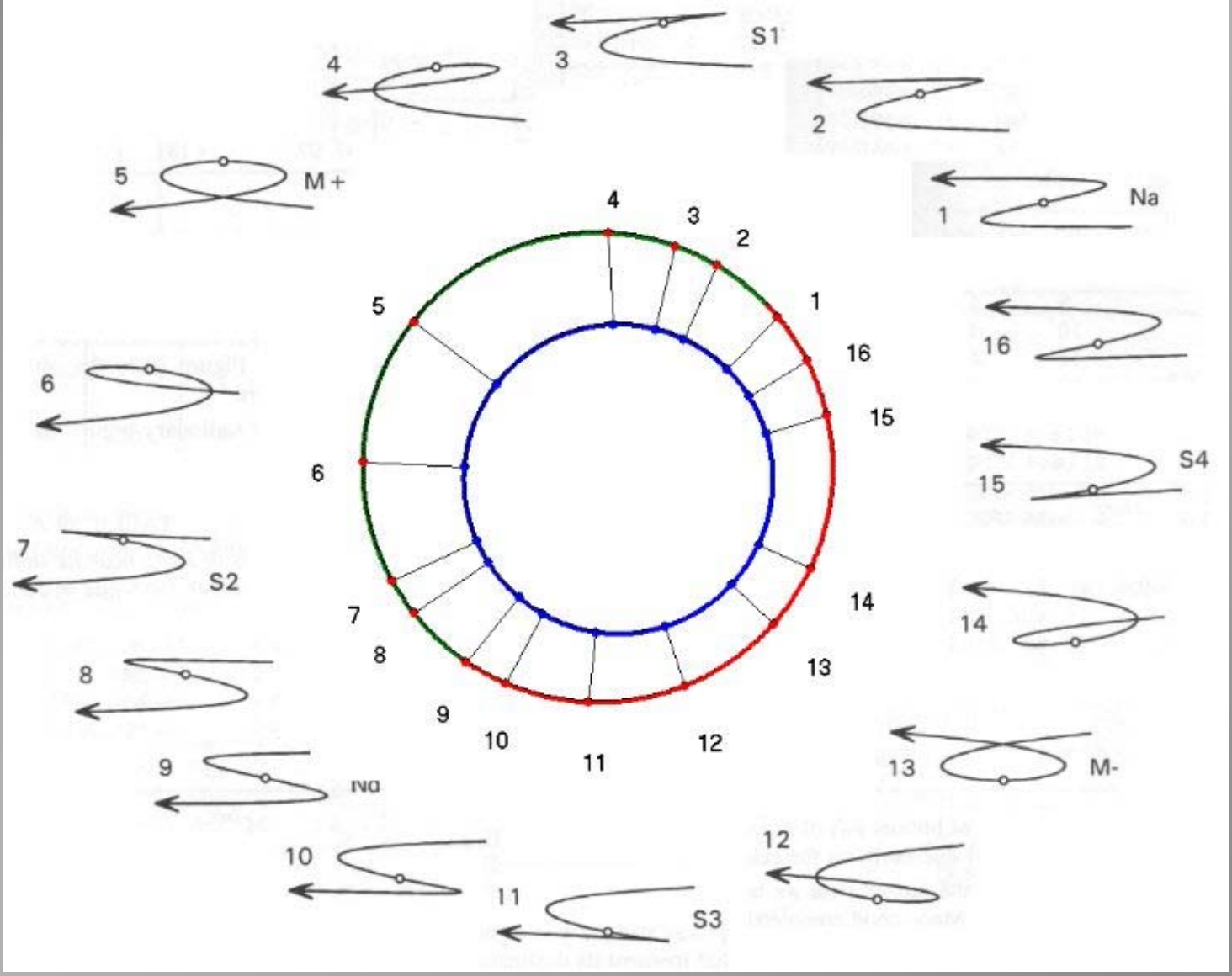
As outer planet through the descending node (high to low), retrograde motion gives a dropping “S” shape.



As outer planet moves through ascending node (low to high), retrograde motion gives a rising “S” shape.



Relative motions give 16 basic shapes (so, time of year)!



3) Planetary Alignments – All line up?

- Bad news – can't happen – orbit tilts won't allow it (not all passing through "nodes" at same time)
- What if the orbits were all flat (in same plane)?
- Suppose we started with all planets lined up initially, when will they line up again?
  - Sorry – still can't line up again!! Doh!

Synodic Periods – example 1

- It has to do with the **synodic** periods with Earth (time to meet up again – conjunction!)
- Hypothetical system (three planets):
  - Planet 1 – 1 year to orbit (Earth)
  - Planet 2 – 2 years to orbit
  - Planet 3 – 3 years (didn't see that coming huh?)
- How long until aligned again – 6 years!
  - Least common multiple of the others

Synodic periods – Example(s)

- What if the periods were 1 year, 3 years and 4 years
  - Now realignment time = 12 years
- What if the periods were 1 year, 4 years and 6 years
  - Still 12 years
  - Factors – 1 =1 4 = 2^2 6 = 2, 3
  - Least common multiple = factors with highest powers multiplied together … {2^2}x3 = 12
- As we use more precision in the periods … time to align approaches infinity (thus, can't do it ..)

PlanetAlign demo

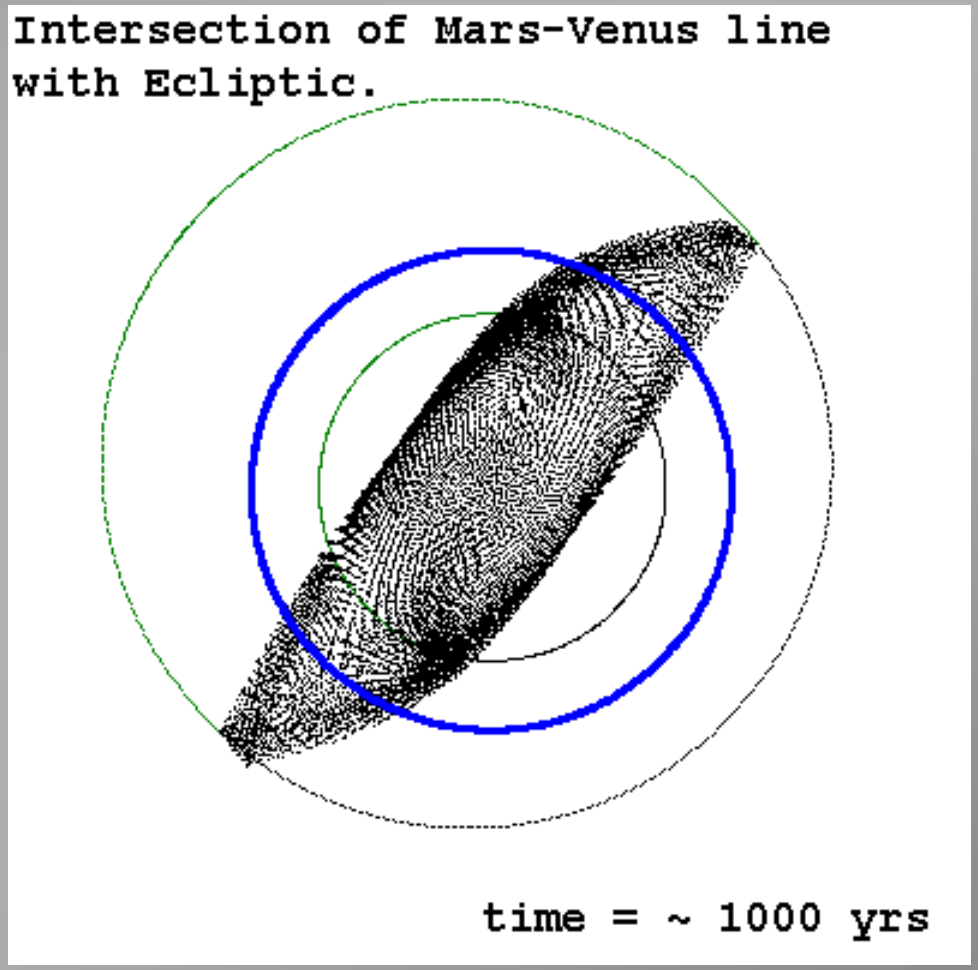
What about Marvin (the Martian)?

He wanted to blow up the Earth because it blocked his view of Venus!

http://en.wikipedia.org/wiki/Marvin_the_martian

Conditions for blocking ..

- How often does Earth block Venus?
- Calculate the location where the Venus-Mars line crosses the ecliptic – if the Earth is there also – block!
- Notice nodes!!



After the computer pulled a few all-nighters …

From the year 1000 to 3000 …

Only one time =

Nov 8th, 2746 ~ 7:45 pm (UT)

Skygazer Demo

Conclusion …

To borrow a phrase from my brother … Marvin the Martian is just a big foo-foo head!!

External links (for sky stuff)

- http://www.heavens-above.com (What's in the night sky – satellite predictions, etc.)
- http://www.fourmilab.ch/homeplanet/ (Orrery {solar system view} + time-step control)

References

Jean Meeus is an Astronomer from Belgium – does some absolutely amazing astronomical calculations. Has many excellent books :

Astronomical Algorithms

Astronomy Morsels

More Astronomy Morsels

Astronomy Morsels III

… please .. MORE!!

Blatant plug for my other talk ..

- Sponsored by SPS (Society of Physics Students)
- Friday Feb 24th – 12 noon S304
- Topics include:
  - Solar system barycenter *(Dr. Scott is not the center?)*
  - Earth/Moon barycenter
  - More on planetary “occultations”
    - one planet blocks the other one
    - Do both outside planets see the same thing??
- A little more technical …

This talk, and other exciting things can be found …

http://qbx6.ltu.edu/s_schneider/astro/index.shtml

Thank you,
Good Night,
Drive Safely!