Intermediate Question: T-8

“Star of Bethlehem”

T-8, Star of Bethlehem

Conjunctions of Moon, Venus and Jupiter on 1st December 2008 [Credit: NARIT]

Motivation

- Planet conjunctions
- Two or more planets lie along same line of sight

Conjunctions of Venus and Jupiter on 13st November 2017 [Credit: Twitter @irvb]

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Motivation

- Great conjunction
  - Conjunction of Jupiter and Saturn
  - Next conjunction on will be on 21st December 2020 with 6 arcmin angle separation between two planets

Great conjunction on 21st December 2020 [Credit: Stellarium]

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Motivation

- Star of Bethlehem
  - In 1606, Johannes Kepler determined that there was a series of three great conjunctions (greatest conjunction) in the year 7 BC that could have been the Star of Bethlehem

A series of great conjunction from Kepler's book De Stella Nova (1606)

Star of Bethlehem [Credit: BBC]

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Objectives

The ultimate goal is **to find which constellation the great conjunction occurred in 7 BC.**

1. Average great conjunction period and heliocentric angle between two successive great conjunctions
2. Constellation of the great conjunction on 21st December 2020
3. Constellation of the great conjunction in 7 BC
4. Constellation of the Sun at the second conjunction of the series of three conjunctions in 7 BC

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Task 1 (6 marks)

- Determine the average great conjunction period
- Assume that the average Earth's orbit is at the Sun.
- Synodic period between Jupiter and Saturn

$$\frac{1}{P_{Synodic}} = \frac{1}{P_{Jupiter}} - \frac{1}{P_{Saturn}}$$

$$P_{Synodic} = 19.86 \text{ years}$$

- Determine heliocentric angle between two successive great conjunctions

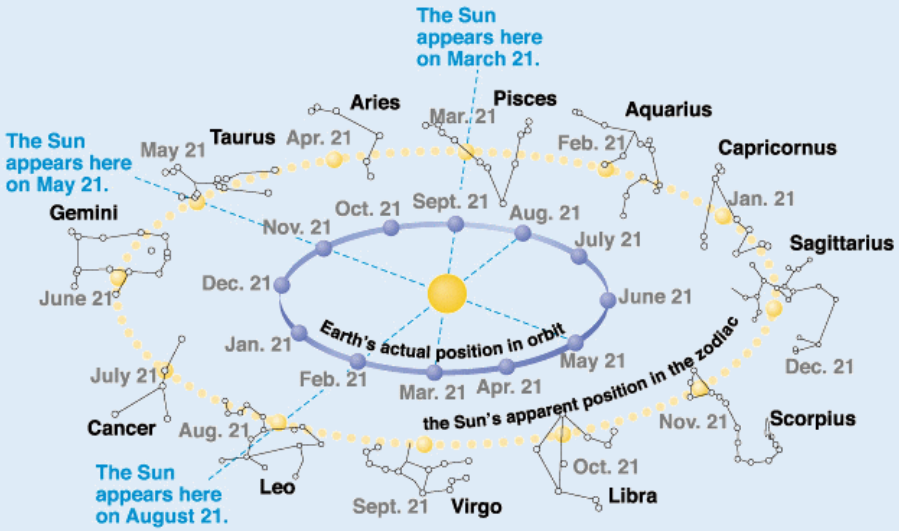
$$\text{Heliocentric angle} = \frac{19.86}{11.86} \times 360^\circ = 603^\circ = 243^\circ$$ clockwise direction through the zodiac

$$360^\circ - 243^\circ = 117^\circ$$ anti-clockwise direction through the zodiac

Task 2 (3 marks)

- Which constellation will the conjunction on 21st December 2020 occur in

- The Sun is in the constellation of **Sagittarius** on **21st December 2020 (Winter solstices)**
- From elongation angle 30.3°, the conjunction is in constellation of **Capricornus**



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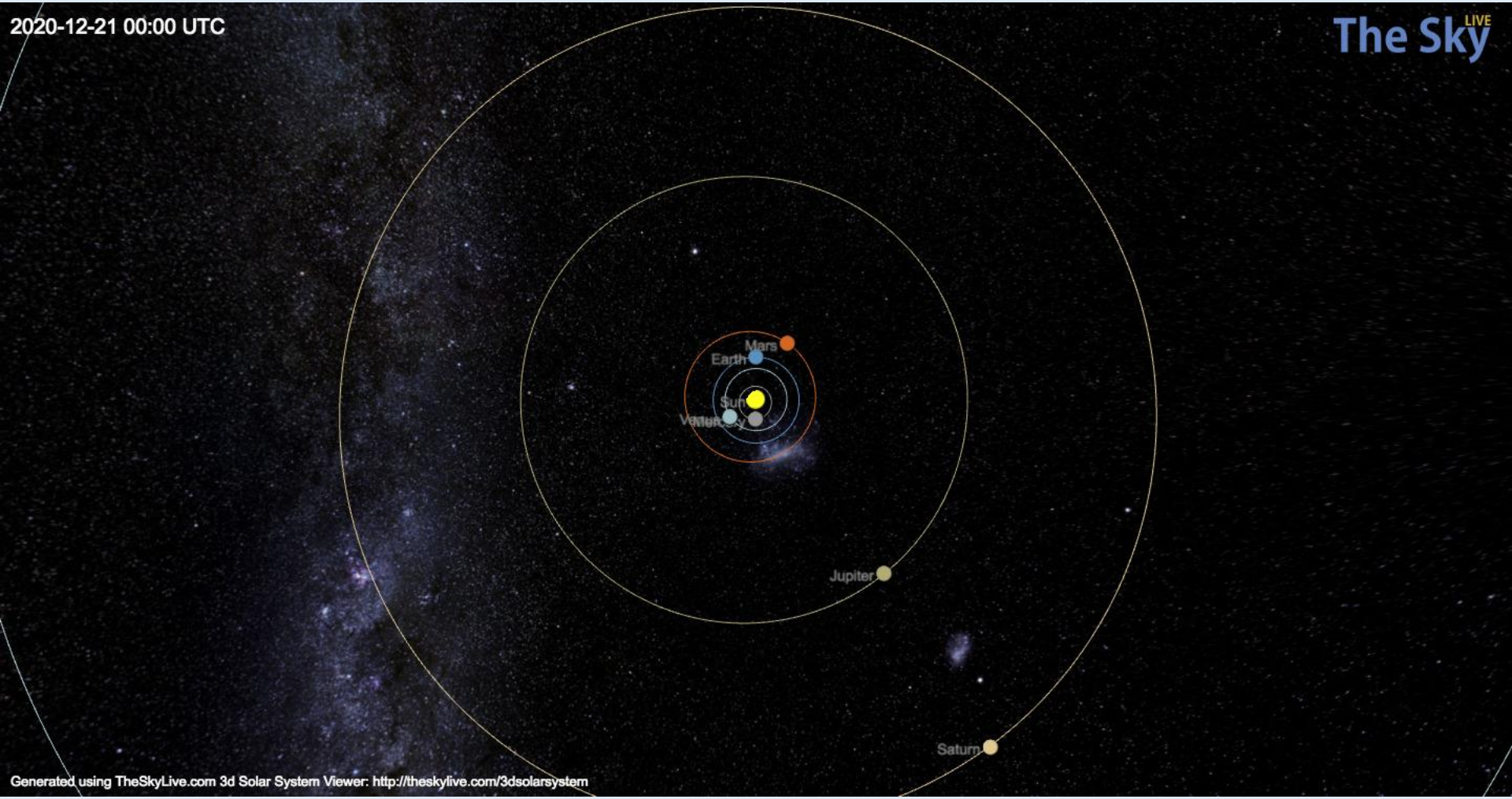

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Task 3 (8 marks)

- **Which constellation did the conjunction in 7 BC occur in**

- Average great conjunction period and and heliocentric angle between two successive great conjunctions *[Task 1]*
- The conjunction in 2020 is in constellation of **Capricornus** *[Task 2]*

- **Students need to determine**
  - Duration and number of conjunctions between 7BC and 2020
  - Angle between 7BC and 2020 conjunctions
  - The conjunction was in constellation of **Pisces**

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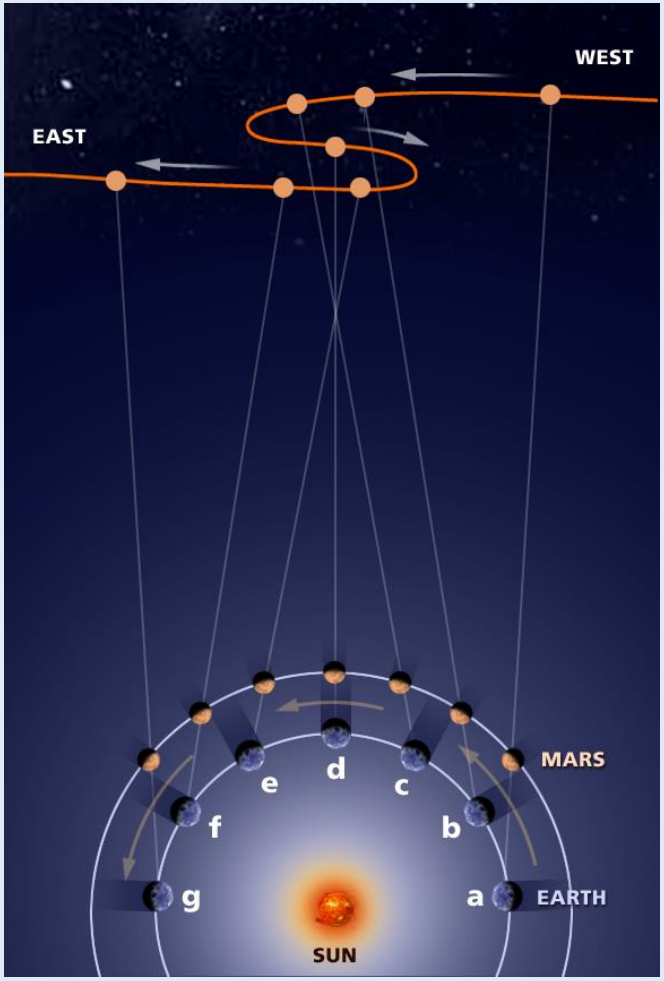
Task 4 (3 marks)

- At the second conjunction of the series of three conjunctions in 7 BC, which constellation was the Sun in

- A series of three greatest conjunctions occurs due to retrograde motion of Jupiter and Saturn
- Jupiter and Saturn were in opposition
- The sun was in the constellation of **Virgo**



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Knowledge

- **Coordinates and times/ Celestial sphere:**
  - Celestial coordinates and their application
  - Equinox and Solstice
  - Constellations and Zodiac

- **Solar System/ The Solar System:**
  - Sidereal and Synodic periods
  - Retrograde motion

Modularity

Task 1

- Synodic period
- Average great conjunction period
- Heliocentric angle between two successive great conjunctions

Task 3

- Conjunction's constellation in 7BC

Task 4

- Sun's constellation in 7BC

Task 2

- Sun's constellation on 20/12/2020
- Conjunction's constellation on 20/12/2020