The use of planisphere to locate planets

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Contents

Abstract

Planisphere is a simple and useful tool in locating constellations of the night sky at a specific time, date and geographic location. However it does not show the planet positions because planets are not fixed on the celestial sphere. It is known that the planet orbital planes are nearly coplanar and close to the ecliptic plane. By making reference to the rise or set time of the planets, the planisphere can in fact be used to locate the planets in the sky as well. This method helps students to rectify the misconception about the positions of the planets in the night sky and promotes a deeper understanding of the planet orbital motions from a topocentric view.

Introduction

There is a common misconception to most people that planets could possibly appear anywhere in the night sky. One of the causes of this misconception may stem from the mixing up of stars and planets because both types of objects appear as points of light to the naked eyes. Since stars appear across the sky, most people also think that the planets could be anywhere in the sky. The other cause is that most people do not realize the orbits of the planets are very close to the ecliptic, i.e. the path of the Sun which appears to move annually in the celestial sphere (Figure 1). Thus the planets are confined to appear only in places which are near the ecliptic plane.

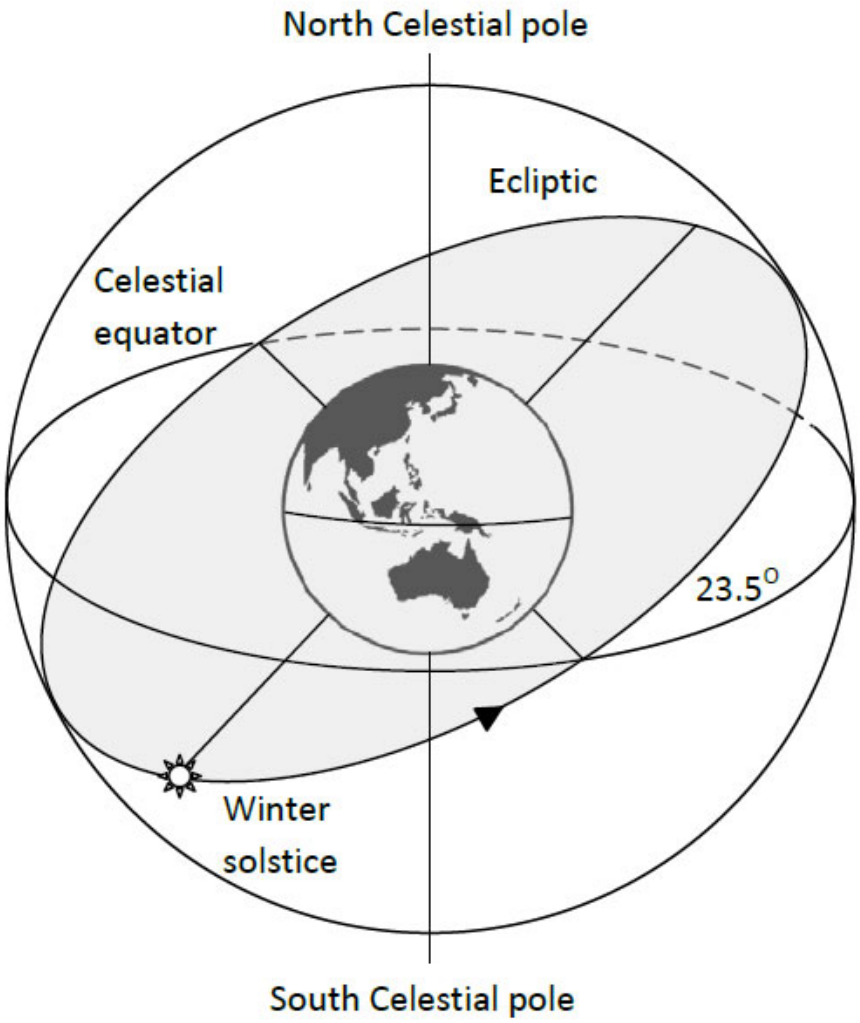

Figure 1. The apparent annual motion of the Sun on the celestial sphere

To help students correct the misconception and develop the concept that the orbits of planets are coplanar, using plainsphere to locate planets is a practical learning activity which can promote a deeper understanding of the concept. The property that orbital planes of the planets are coplanar is not coincident and has its origin in the formation of the solar system (Goldreich, Lithwick, & Sari, 2004).

Planisphere has long been used by many novices or even experienced observers to identify constellations and stars in the night sky (Hughes & Stott 1995). It is convenient, inexpensive and easy to use. Even beginners can use it skillfully with little training. Though the planisphere is suitable for finding constellations and bright stars, it does not show where the planets appear in the sky because the positions of the planets are not fixed on the celestial sphere. This deficiency causes inconvenience to observers because the planets are one of the interesting observation objects and they are also very appealing to novice observers. To extend the application of planisphere in finding planets, some planispheres provide the positions of the planets in tables, showing the constellation or the coordinates of each planet within a certain range of years on the backside of the planisphere (e.g. Philip's planisphere) or in a separate booklet (e.g Edmund Scientific planisphere). Thus most people think that planisphere cannot be used to locate the planets without such information ("Planisphere", n.d.).

Electronic star map, which is available as app in mobile devices, overcomes this drawback and makes stars and planets identification much easier. Despite an increasing popularity of star map app for mobile phones and tablets, planisphere still has its edge over electronic star map in terms of price, simplicity and pedagogical value.

The Principle

If we know the rise or set time of the planets, it is possible and easy to use the planisphere to locate the planets. The idea is simple. First, the planets are always near the ecliptic because the inclinations of the orbital planes of the planets are only a few degrees from the ecliptic (JPL Solar System Dynamics Group, n.d.).

Table 1. Inclinations of planetary orbits

Planet	Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune
Inclination of planetary orbits (degrees)	7.00	3.39	0	1.85	1.30	2.49	0.77	1.77

In the planisphere, the ecliptic is represented by an off-center circle on the circular star chart (Figure 2). Some planispheres may not have the ecliptic drawn but the users can roughly estimate the ecliptic because the ecliptic runs through the zodiac constellations. Since the planets must appear near the ecliptic plane, the issue is to determine at which points on the ecliptic path the planets lie.

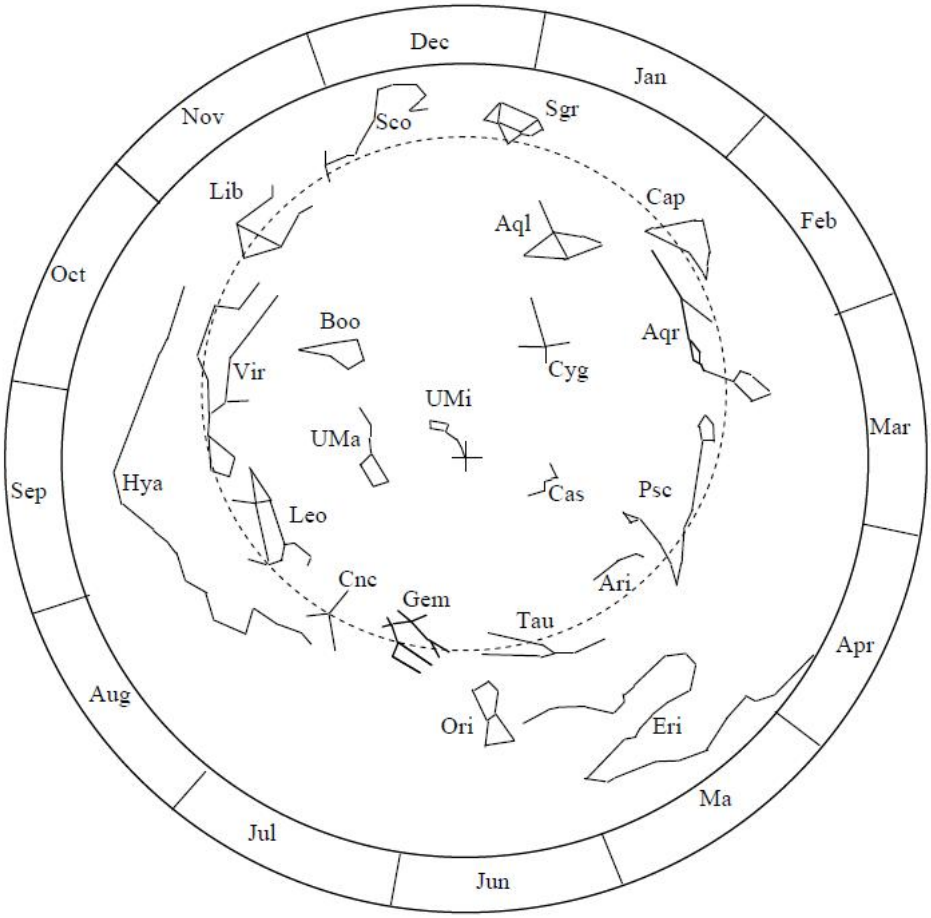

Figure 2. Circular star chart of the planisphere with ecliptic shown in dotted line.

The part of the sky being visible at any particular time and date appears in an oval window of the cover overlaid on the circular star chart (Figure 3). The oval window represents the horizon of the observation location. The oval boundary intersects the ecliptic at two points, one at the east horizon and the other at the west horizon (Figure 4).

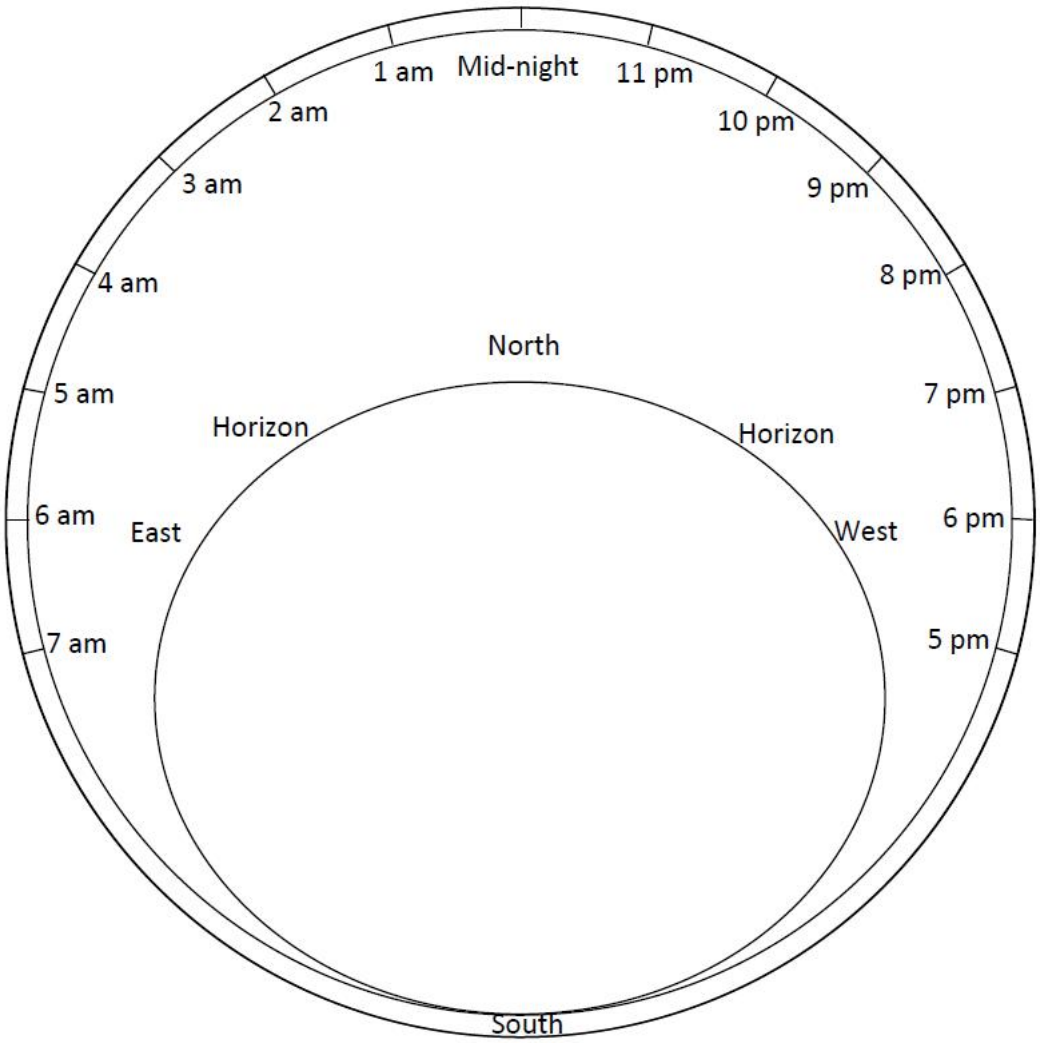

Figure 3. An oval shape window in the cover to show the part of the sky at a specific time and date

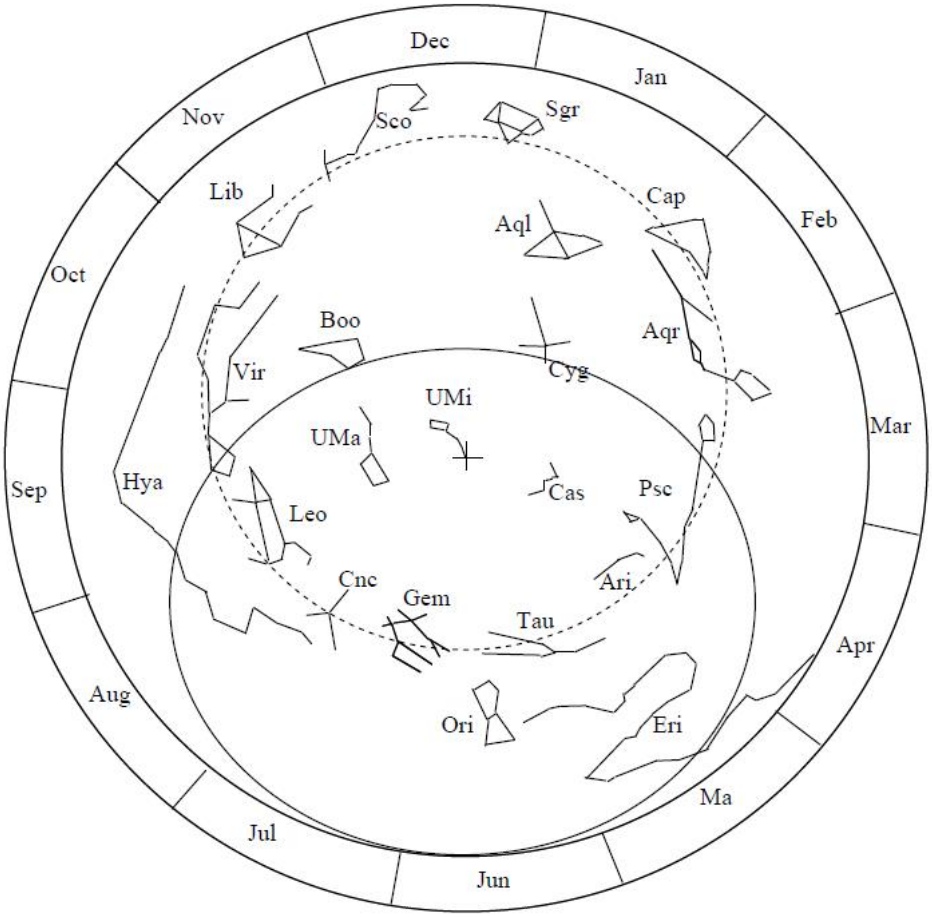

Figure 4. The oval shape horizon boundary intersects with the ecliptic at two points, Virgo (Vir) in the east and Pisces (Psc) in the west

If we set the planisphere at the rise or set time of the planets, the intersecting points are the positions of the planets. The example in Figure 4 shows that the planet risen on the east horizon is in Virgo (Vir) and the planet set on the west horizon is in Pisces (Psc). Figure 5 shows these two intersecting points in a topocentric view. Therefore if we know the rise and set times of the planets, we can determine the location of the planets.

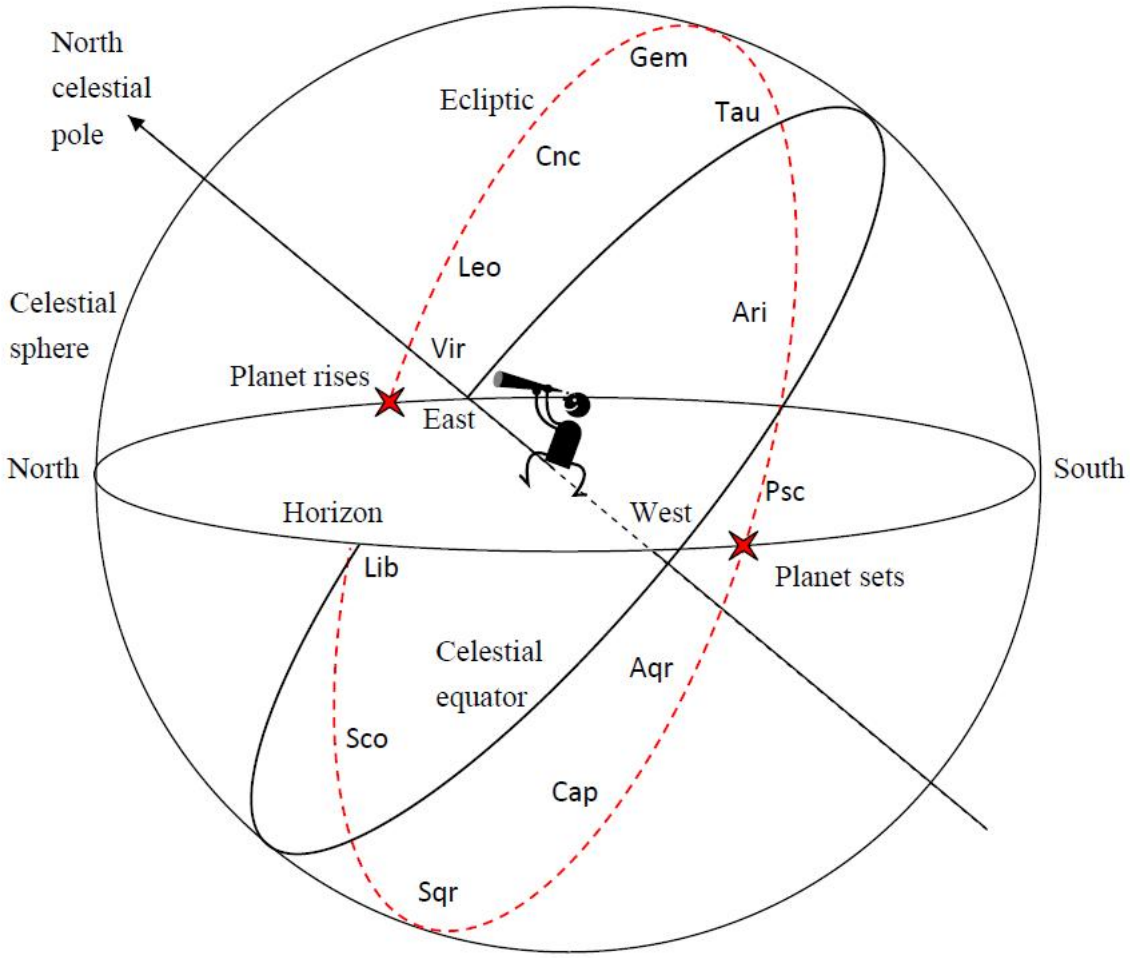

Figure 5. Topocentric view of the celestial sphere at a location in the northern hemisphere. The ecliptic, running through the twelve constellations of the zodiac and represented by dotted line, intersects with the horizon at two points

The next thing we need to know is the rise and set times of the planets. Fortunately this information is easily accessible. The rise and set times of the planets are published by local observatories. They are also available at these websites.

(a) Astronomical Applications Department of the U.S. Naval Observatory

http://aa.usno.navy.mil/data/

Rise/Set/Transit Times for Major Solar System Objects and Bright Stars

(b) HM Nautical Almanac Office

http://astro.ukho.gov.uk/websurf/

Rising and setting times of Sun, Moon or planet

The rise and set times of planets may also be presented in a graph such as the one given by the Hong Kong Observatory (2013).

Discussion and Conclusion

The accuracy of this method to locate the planets using the planisphere is accurate to a few degrees because the planets are within a few degrees from the ecliptic plane. Even with a minor discrepancy, the accuracy is good enough for us to use the planisphere to locate the planets. Such accuracy is better than just indicating the positions of the planets by making reference to constellation only. In the example in Figure 4, Virgo extends more than 30 degrees along the ecliptic. The intersecting point of Virgo with the ecliptic is in fact toward one of its ends near the Leo. If we only specify the position of the planet to be in Virgo, the uncertainty of its exact location is much greater.

Pedagogically, this method requires higher order cognitive skills as compared with the way to obtain the location of the planets from reading off the information from tables. First, students need to understand that the planet orbits are nearly coplanar and close to the ecliptic. Next, they also need to exercise their spatial thinking skill to determine the intersection of the ecliptic plane with the horizon. The thinking process helps students to develop and consolidate the concept of the celestial sphere as seen from the surface of the earth.

There are many misconceptions held by students about the planets and the solar system (Sadler 1992). Misconceptions are hard to alter. To change the misconceptions by simply presenting the correct concepts through lectures and reading text are not effective. Only when learning involves high order thinking skills and students' knowledge is challenged, the concepts could then become internalized. Thus instructional strategies should include learning activities which require higher order cognitive skills in order for students to reconstruct their own knowledge. In view of this, by extending the application of the planisphere to locate planets, a practical learning activity introduced in this article, could be a useful tool for such purpose.

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