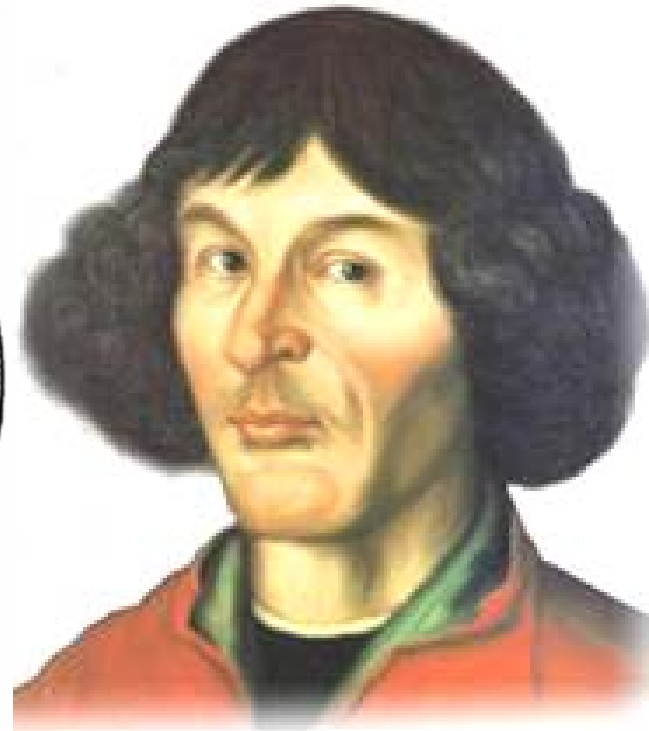


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寫給當代的經典

Nicolaus Copernicus, 'On the Revolutions of Heavenly Spheres'



哥白尼
天體運行論

朱明中

香港中文大學物理系

NICOLAI COPERNICI TORINENSIS
DE REVOLUTIONIBVS ORBI-
um cœlestium, Libri VI.

.Habes in hoc opere iam recens nato, & ædito, studiose lector, Motus stellarum, tam fixarum, quàm erraticarum, cum ex ueteribus, tum etiam ex recentibus obseruationibus restitutos: & nouis insuper ac admirabilibus hypothesibus ornatos. Habes etiam Tabulas expeditissimas, ex quibus eosdem ad quoduis tempus quàm facillime calculare poteris. Igitur eme, lege, fruerere.

Ἀγαμέμνωνος ὕδατος εἰσὶται.

Norimbergæ apud Ioh. Petreium,
Anno M. D. XLIII.

哥白尼〈天體運行論〉
1543年春天出版

http://www.bj.uj.edu.pl/bjmanus/revol/titlpg_e.html

‘Perhaps there will be babblers who claim to be judges of astronomy although completely ignorant of the subject and, badly distorting some passage of Scripture to their purpose, will dare to find fault with my undertaking and censure it. I disregard them even to the extent of despising their criticism as unfounded. For it is not unknown that Lactantius, otherwise an illustrious writer but hardly an astronomer, speaks quite childishly about the Earth's shape, when he mocks those who declared that the Earth has the form of a globe. Hence scholars need not be surprised if any such persons will likewise ridicule me. Astronomy is written for astronomers.’

<http://www.webexhibits.org/calendars/year-text-Copernicus.html>

哥白尼 <天體運行論>

- 歷史背景
- 哥白尼為甚麼要建構日心說?
- 為甚麼哥白尼的學說推動了科學革命?

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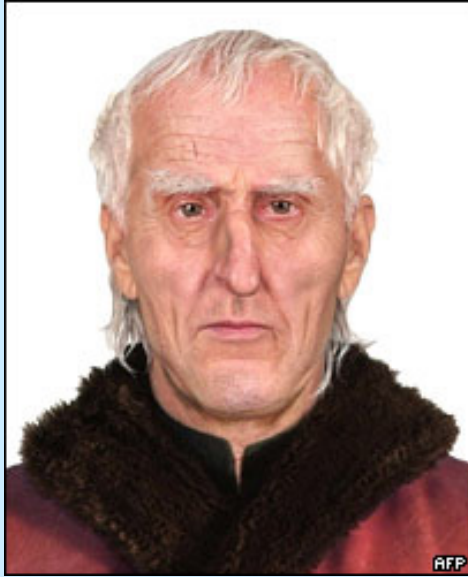
A. Rupert Hall, *The Revolution in Science 1500-1750* (Longman, London, 1983).

O. Gingerich, *The Book Nobody Read: Chasing the Revolutions of Nicolaus Copernicus* (Walker, New York, 2004).

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<太陽系理論的突破>，大學通識報第3期，第133—151頁 (2007)。

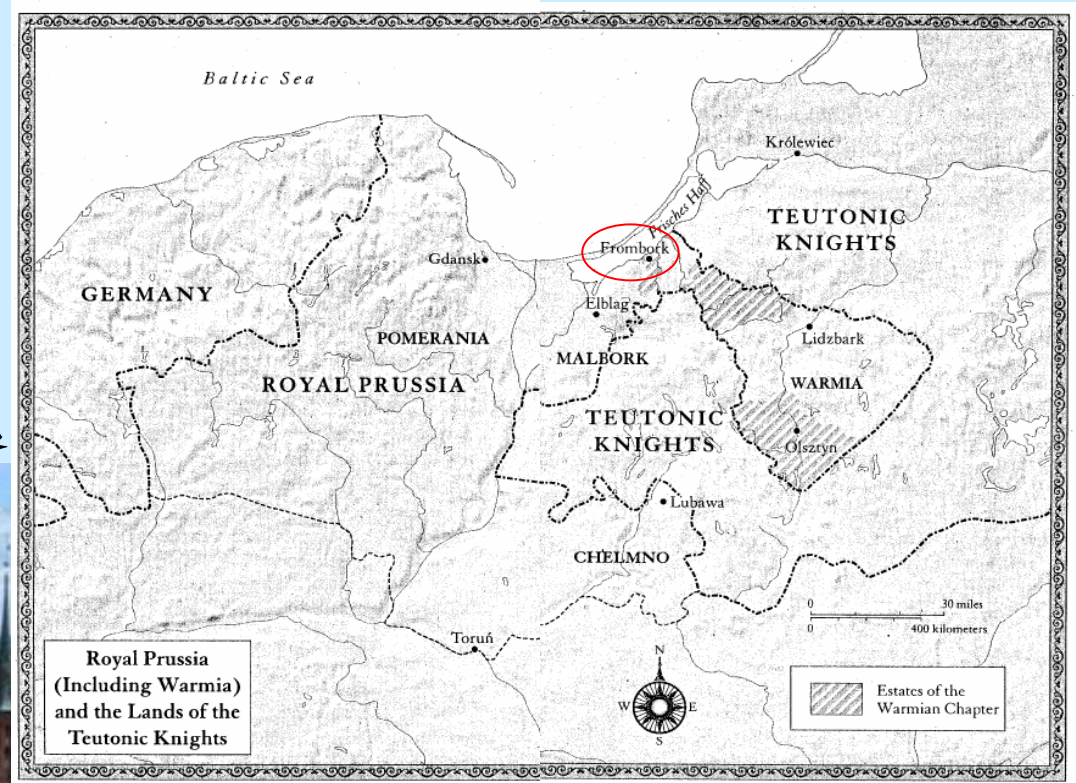
<http://www.cuhk.edu.hk/oge/rcge/publication/bulletin.htm>

歷史背景



哥白尼七十歲時的面貌
(科學鑑證重塑)

<http://news.bbc.co.uk/1/hi/world/europe/4405958.stm>



Frombork大教堂: 哥白尼遺體存放處



From J. Repcheck, *Copernicus' Secret*,
Simon & Schuster, 2007.



哥白尼生平:

<http://www.frombork.art.pl/Ang11.htm>

Life of Nicolaus Copernicus

- 19.II.1473 Nicolaus Copernicus born at Torun, Poland
- 1483 Copernicus' father dies
- 1489 Lukasz Watzenrode, Copernicus' maternal uncle and guardian, elected Bishop of Warmia.
- 1491 Nicolaus Copernicus leaves the parish school of St. John, Torun for the University in Kraków.
- 1491-1495 Period of studies at the University in Krakow.
- 1496 Copernicus begins Law studies at Bologna.
- 1497 Copernicus join the Chapter of Warmia, holding the post of Canon of Frombork in absentia through his vicars. His name is entered into the students' corporation
- 1501 Copernicus completes his fourth year of studies; his three year leave of absence from duties as Canon to the Chapter House expires; he goes to Frombork and requests two year extension of his leave to complete his studies. The Chapter approves his request. He begins the study of Medicine at Padua while continuing to read Law.

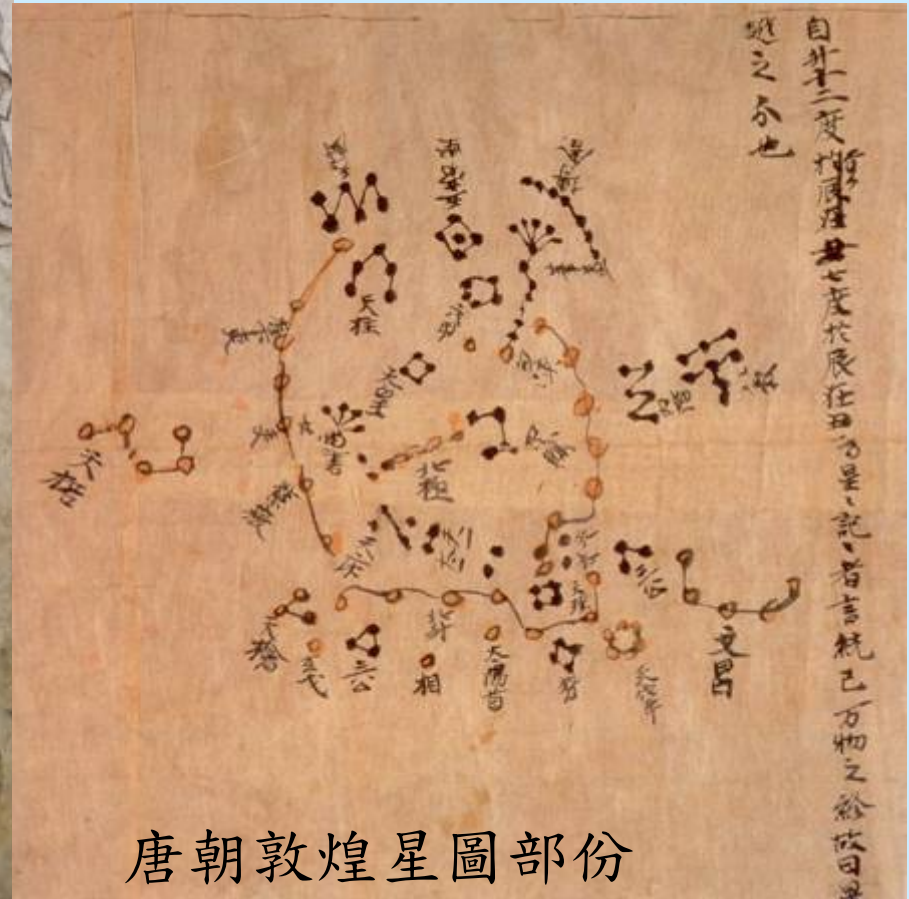
1507	Chapter appoints Copernicus private physician to the Bishop. Works on his Commentariolus which presents theories on motions of celestial bodies containing the first synopsis of his heliocentric theory. This treatise is sent to various persons via a series of letters.
1509-1510	Leaves Bishop's Court at Lidzbark Warmiński and moves to Frombork.
1510-1512	Copernicus draws up a map of Warmia and the western borders of Royal Prussia for the Poznan convention of the King's Council. Copernicus continues to hold both the office of Chancellor as well as Visitor in the Chapter House. 1511 Appointed Chief Bursar in the Chapter.
1519-1520	Outbreak of war between Poland and the Teutonic Knights.
1520	Copernicus is part of the Polish embassy to the Grand Master of the Teutonic Knights requesting restoration of Braniewo, captured by the Teutonic Knights. Reappointed Administrator of the Chapter property. Copernicus organises the defence of Olsztyn against the Teutonic Knights.
1538-1539	Bishop Joannes Dantiscus (Dantyszek) suspects Copernicus of living in concubinage, orders him to send away his housekeeper, and instigates canon law proceedings against him. While Copernicus complies with the request, nothing came of the charges which were eventually dropped.
1539	Georg Joachim von Lauchen (Rheticus), Professor of Mathematics from Wittenberg, visits Copernicus to learn more about his theory and to assist Copernicus in getting De Revolutionibus published.
1540	Appointed Chief Treasurer of the Chapter's building fund.
1541	After much work on revisions, Copernicus gives Rheticus the manuscript of De Revolutionibus for publication.
1542	Copernicus' book on Trigonometry, an extract from certain chapters of De Revolutionibus, published at Wittenberg.
1543	De Revolutionibus Orbium Coelestium published in Nuremberg.
21.V.1543	Copernicus dies at Frombork

十五世紀歐洲醫生手冊



Photo from Encyclopedia Britannica

古人認為星星主宰人生，以至國家大事。占星學/天文學成為重要學問。



唐朝敦煌星圖部份

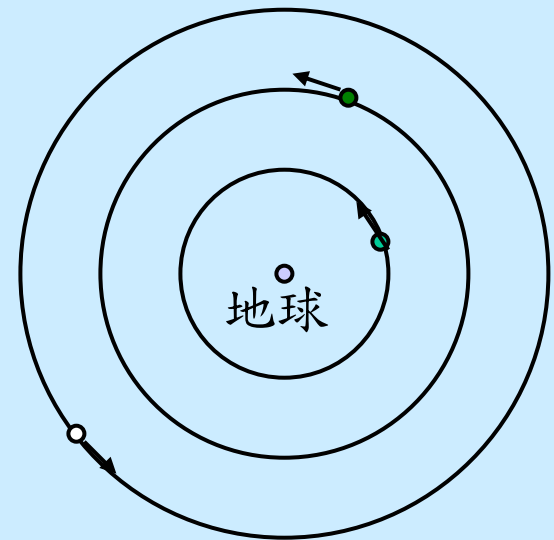
http://en.wikipedia.org/wiki/Chinese_astronomy

已發現最古老的星圖 (~ 705AD)

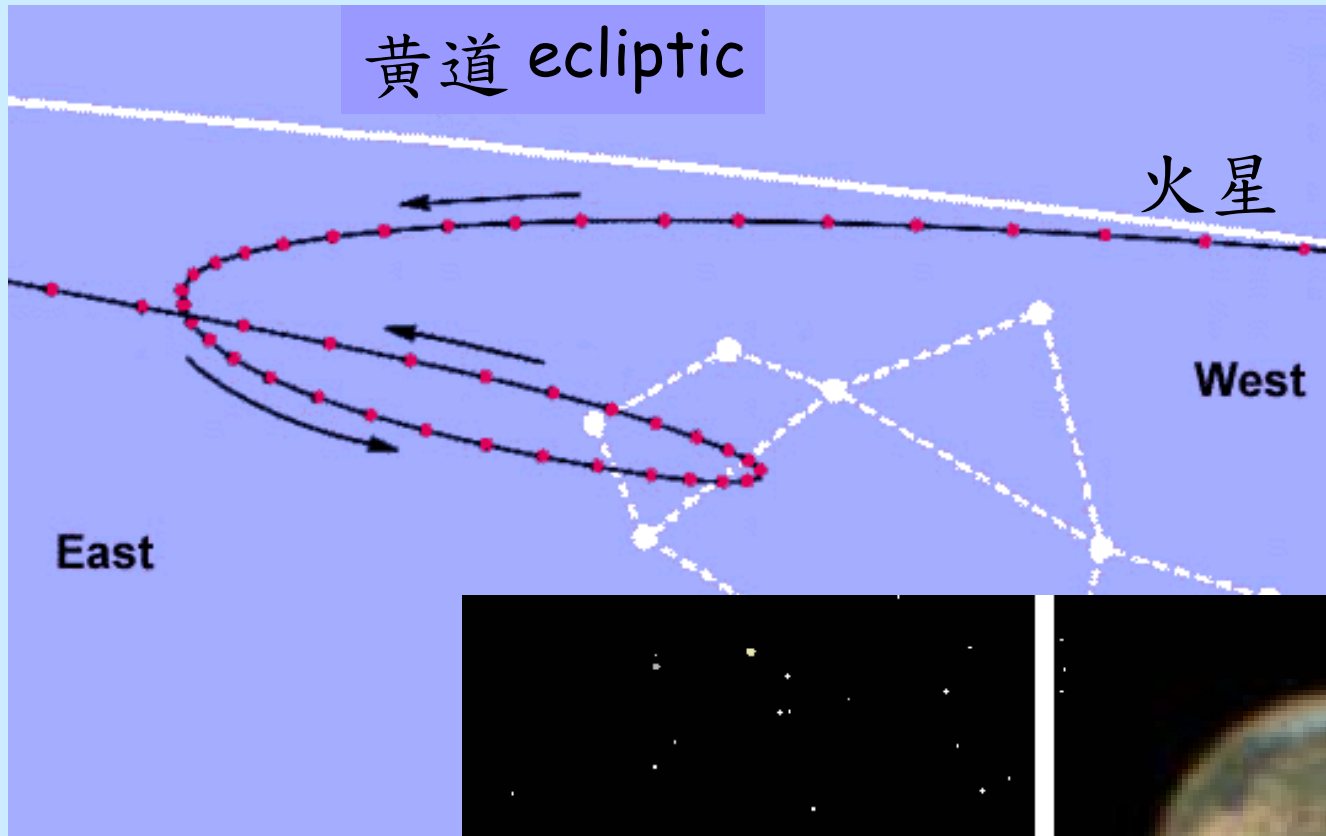
www.britannica.com/EBchecked/topic/39971/astrology/35971/Astral-omens-in-Egypt-Greece-India-and-China

柏拉圖(Plato)-阿里斯多德(Aristotle) 宇宙論

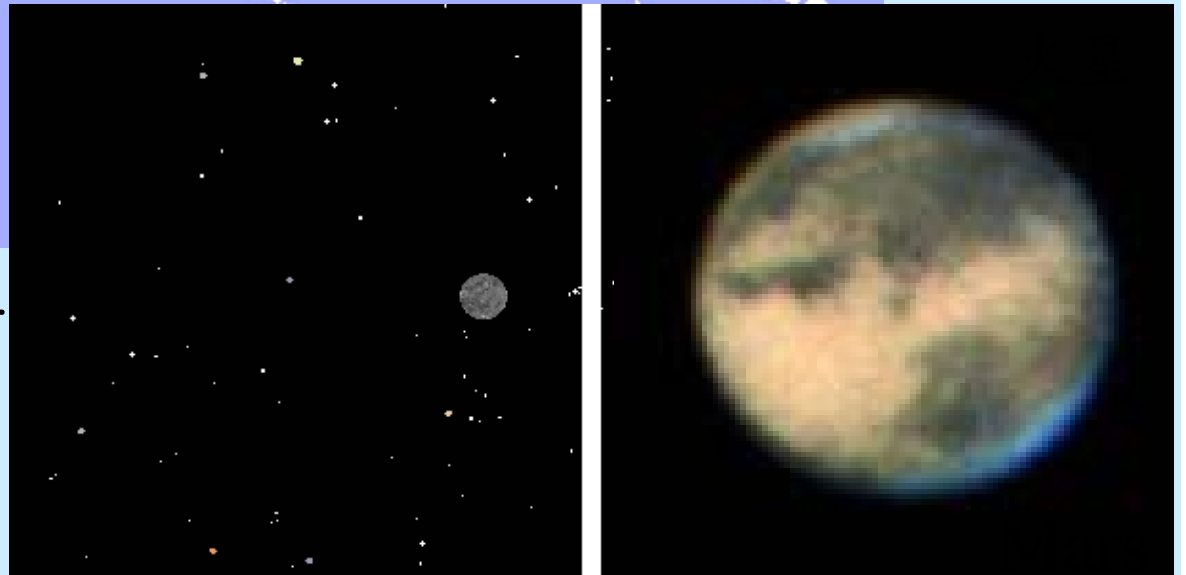
- 柏拉圖：天堂物件皆完美，以完美軌跡運行
→ 天體以圓周均速運動
- 地球為宇宙中心，眾星拱照
- → 多重圓球包圍地球
- 宇宙有限、人類獨一



阿里斯多德系統的缺失



- 逆行現象(retrograde motion)
- 行星及月亮時快時慢
- 行星及月亮時大時小



月球視角度變化



近地點 Perigee

遠地點 Apogee

Photo credit: Galileo Project, NASA

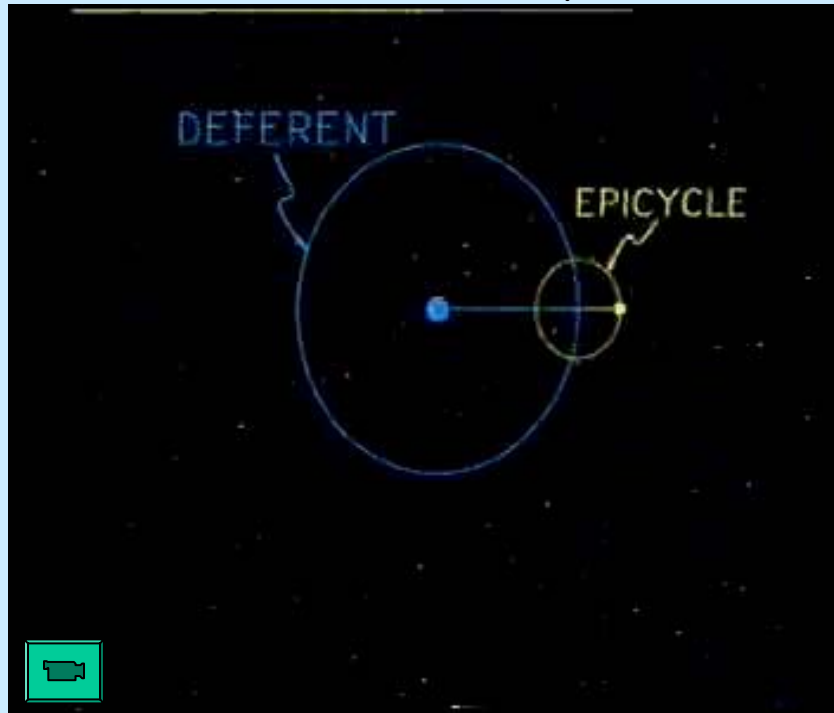
托勒密(Ptolemy)系統

柏拉圖的聖旨：天體以圓周均速運行

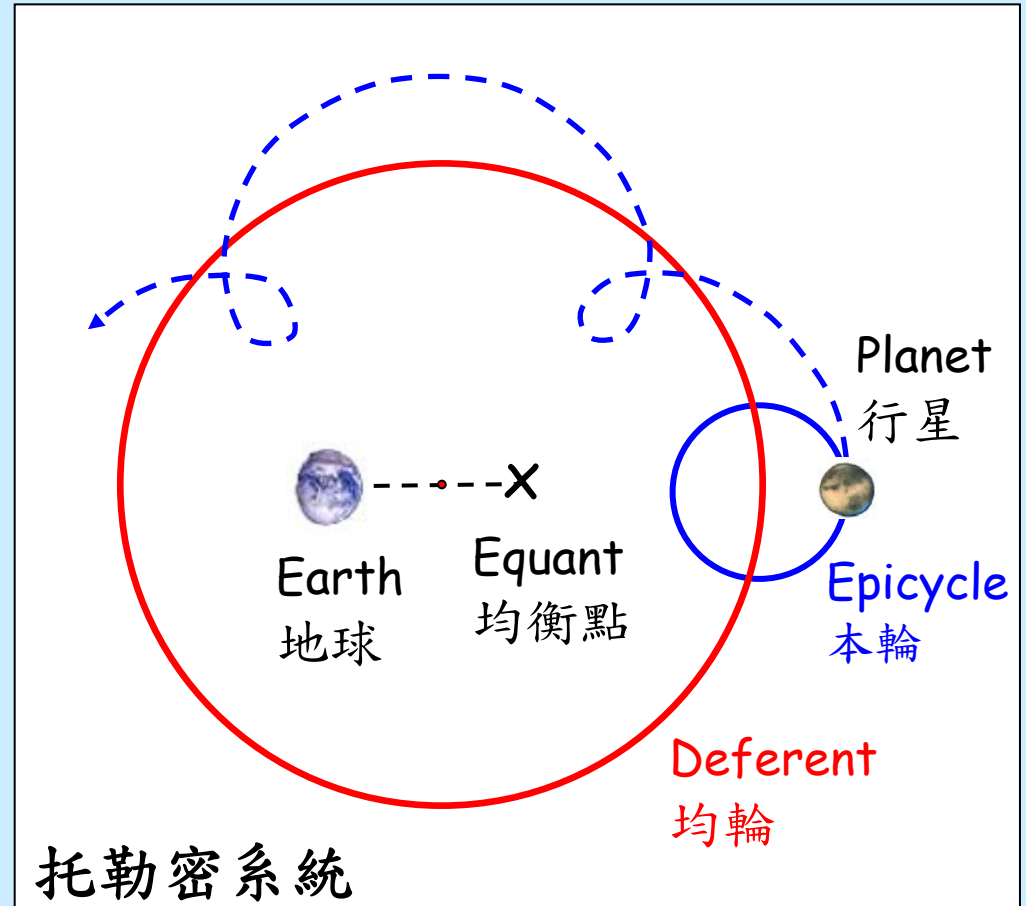
- 行星在均輪(Deferent)上繞本輪(Epicycle)運行
- 地球在偏心點(Eccentric)，非正中心，靜止不動
- 行星相對均衡點(Equant)角速不變



(90-168 AD)

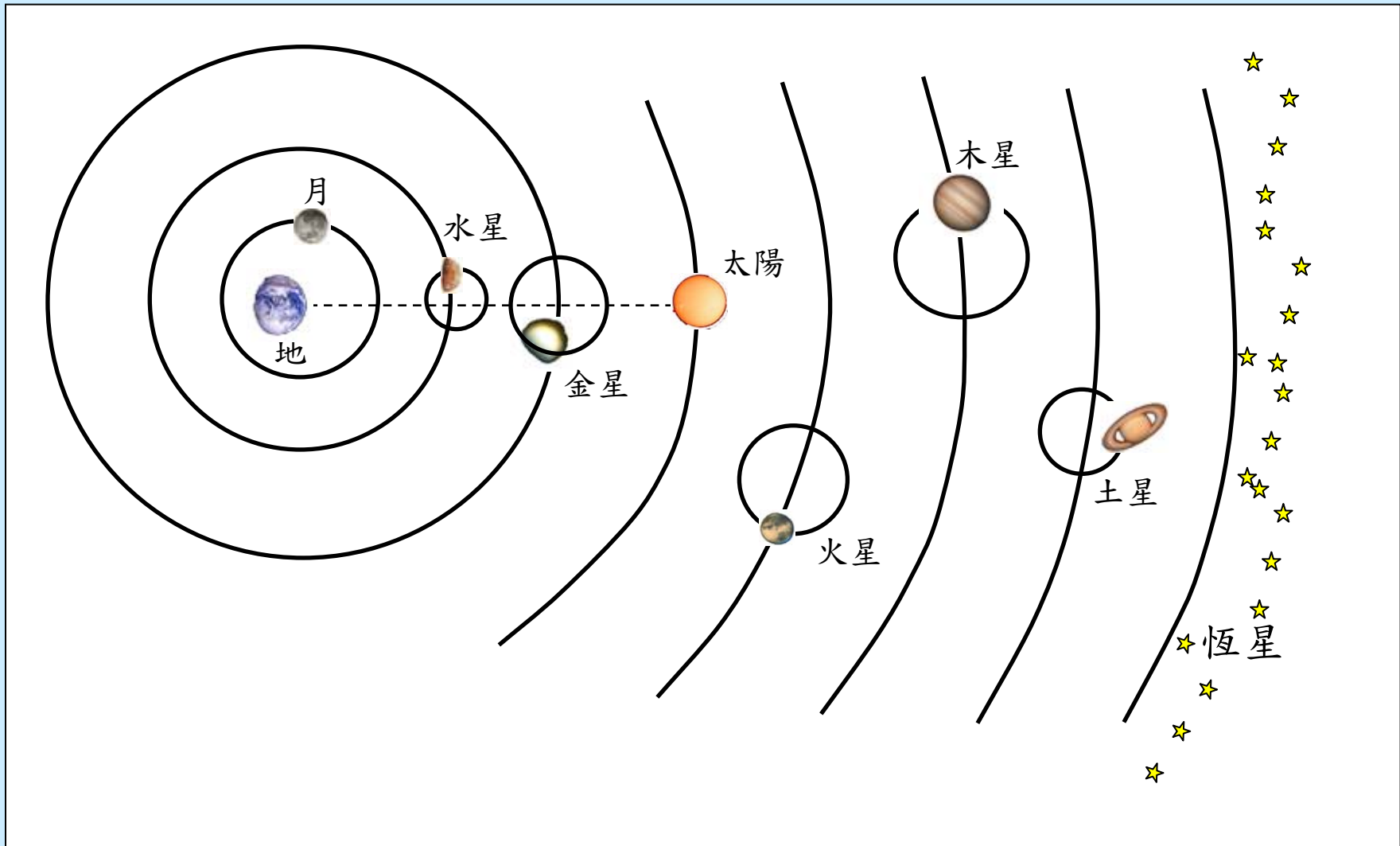


阿波羅尼奧斯(Apollonius),
喜帕恰斯(Hipparchus)

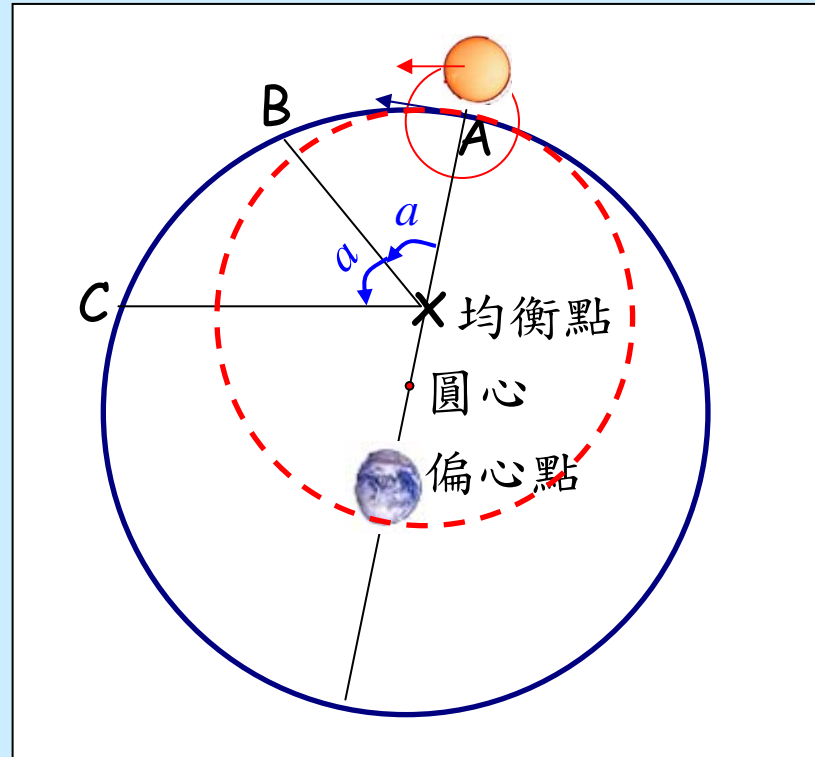


托勒密系統

托勒密系統 (簡化版)



均衡點 (Equant)



相對均衡點均速(紅色虛線): 由A到B所需時間 = 由B到C
相對地心(偏心點)或圓心皆非均速!

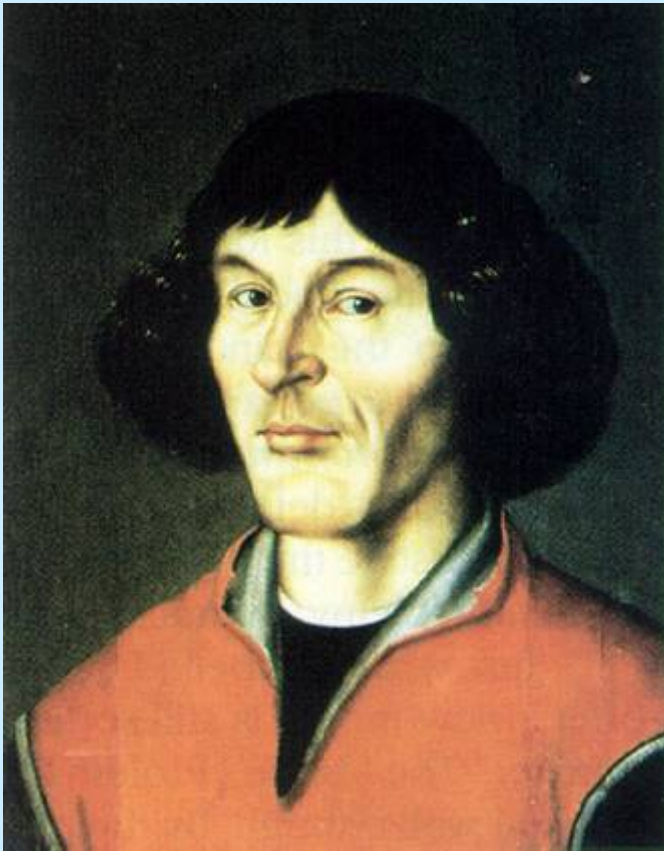
哥白尼: 違反天條!

“Axiom: The movement of the heavenly bodies is regular
except for seeming irregular with respect to appearances.”

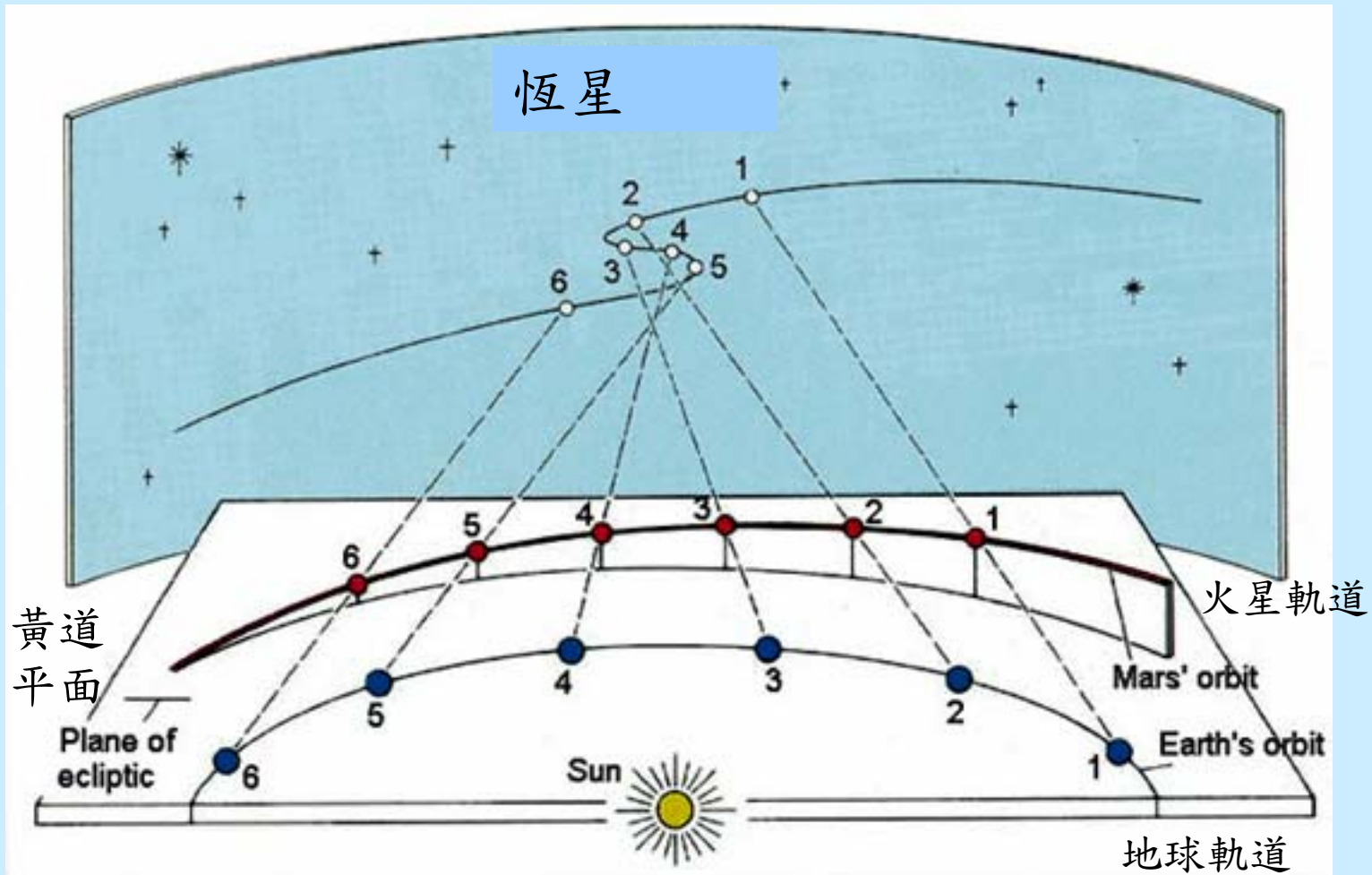
哥白尼日心說 (簡化版)

- 地球及其他行星繞日以圓周軌道運行

Revolution!

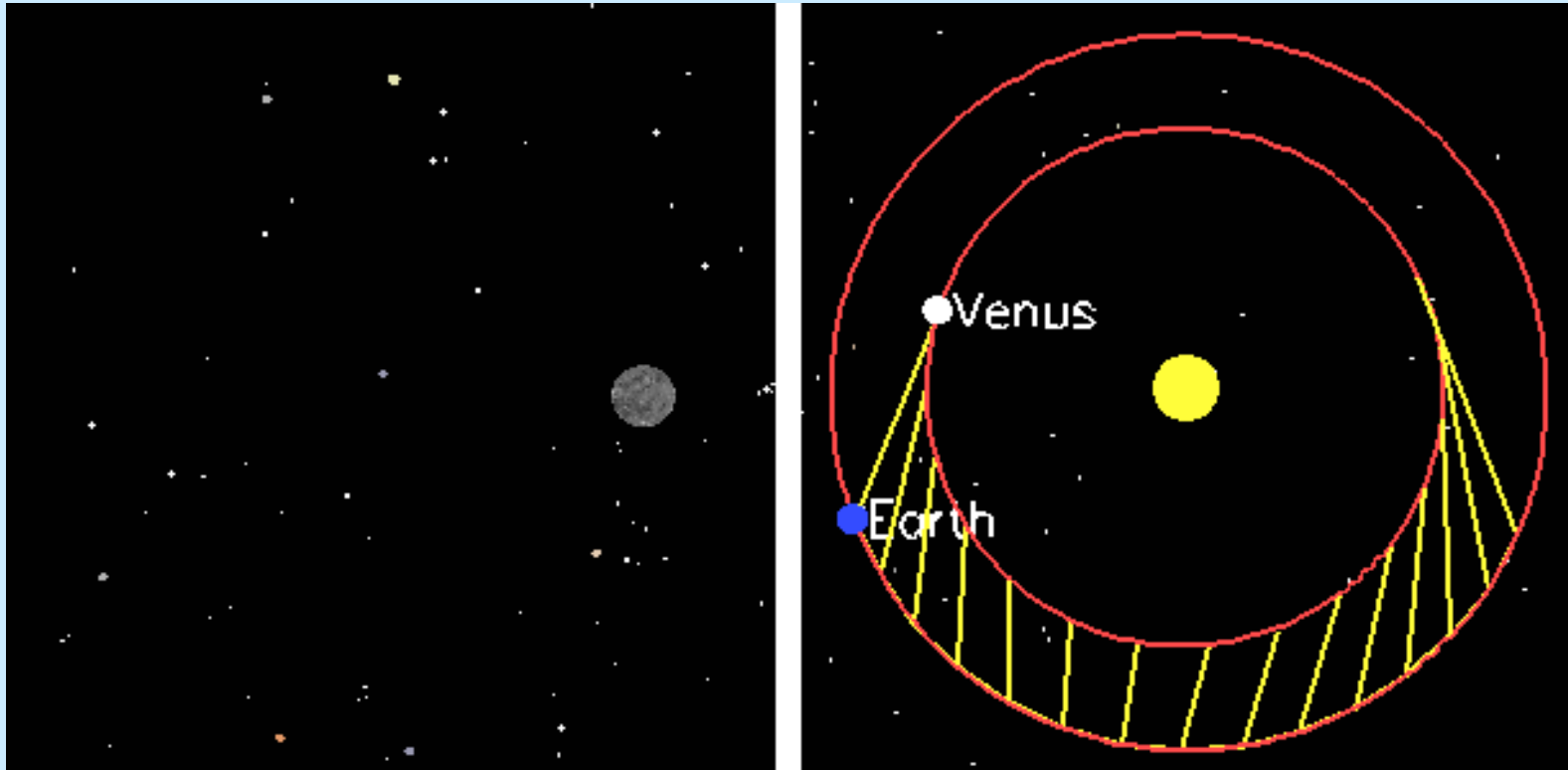


哥白尼日心說



地球在繞日軌道上移動較火星快→視角不均勻改變
→逆行現象

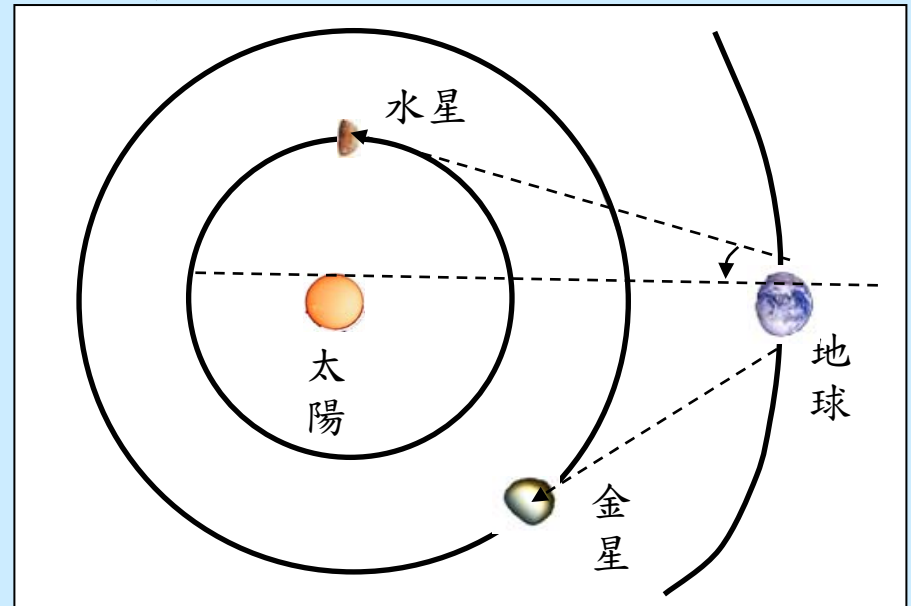
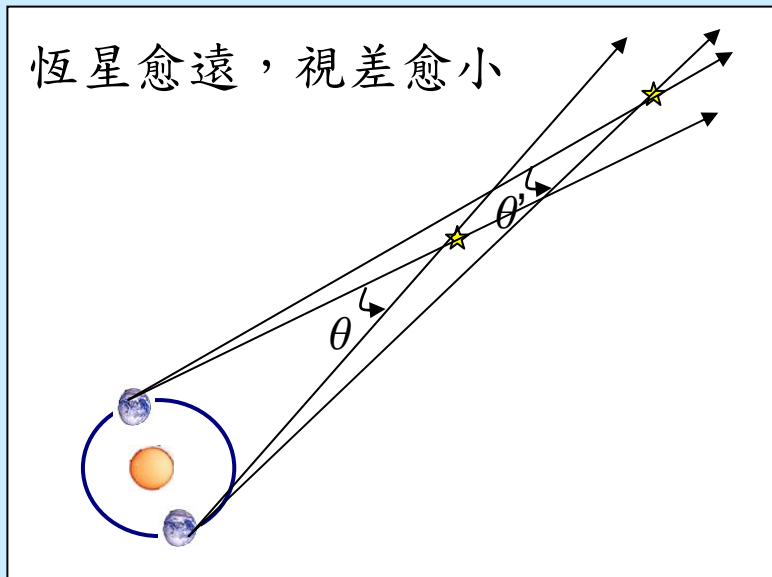
行星逆行



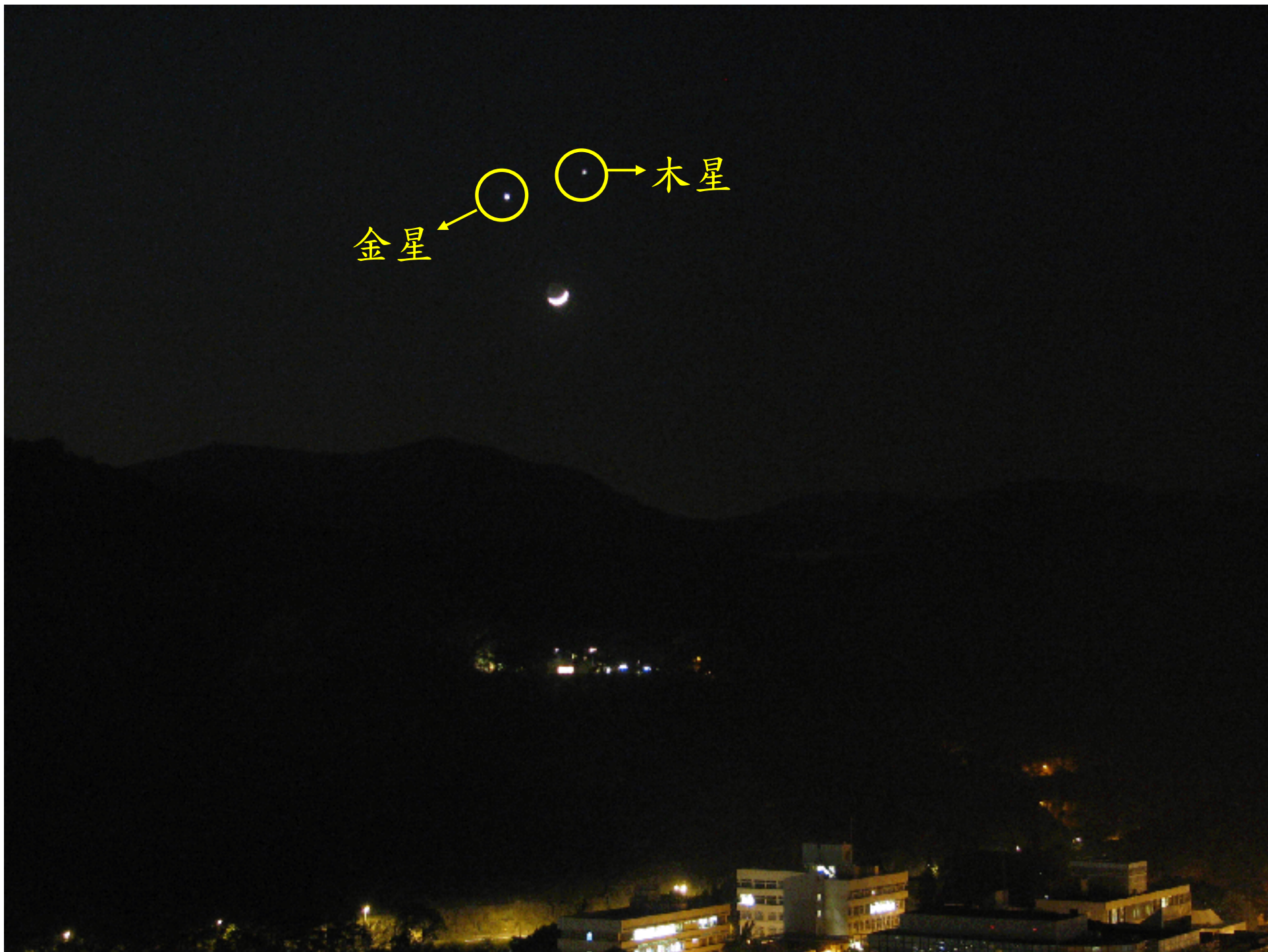
金星在繞日軌道上移動較地球快→逆行現象

哥白尼日心說的成功

- 簡單地解釋逆行現象 (定性卻非定量)
- 簡單地解釋金星及水星出現時間及位置 (晨星或昏星)
- 成功推算出行星排列次序及相對距離
- 預測恆星視差 (parallax)
- 預測恆星非常遙遠 (沒有視差) → 宇宙很大

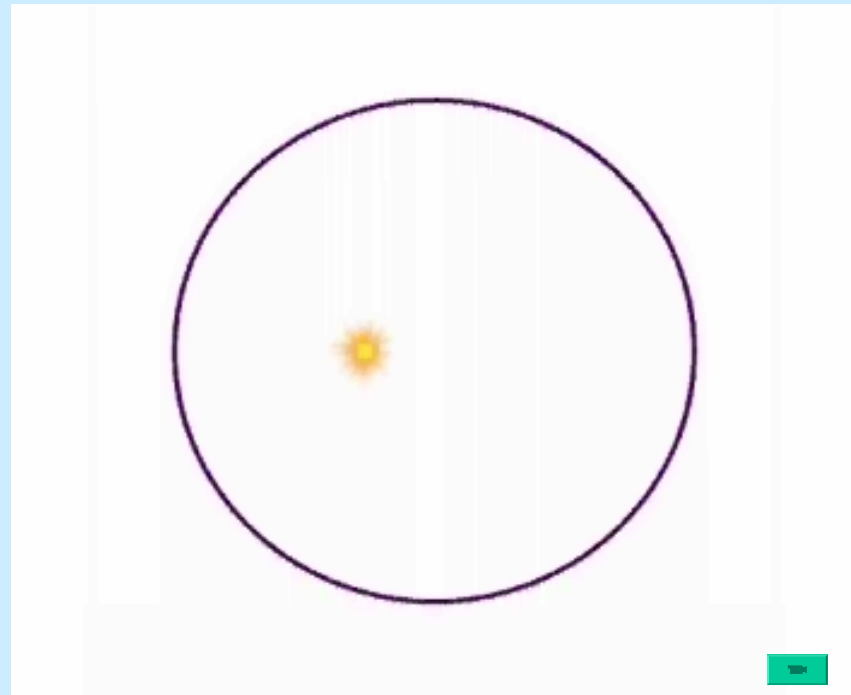


金星 ← ○ → 木星



哥白尼日心說的缺失

- 堅持圓周運動 → 開普勒(Kepler)第一定律
- 行星「均速」運動 → 開普勒第二定律
- 絕對座標: 日不動
- 複雜、不準確



日心說與地心說其實大致一樣

均速運動及位置皆只有相對意義

天文學家霍伊爾說：

兩幅圖畫（地球中心論與太陽中心論）間的關係只不過是區區的座標變換，……任何兩樣觀察宇宙的方式，若彼此關係由於座標變換，則從物理學眼光來看是完全相等的。……我們今天不能在物理學意義上認哥白尼理論為「正確」，托勒密理論為「錯誤」。⁵⁵

‘Omitting minor epicycles and eccentrics, which have no bearing on the harmonies of Copernicus’ system, the Tychonic system is transformed to the Copernican system simply by holding the sun fixed instead of the earth....the only possible difference between the motions in the two systems is a parallactic motion of the stars ...’
T. Kuhn, *The Copernican Revolution*, p. 204.

陳天機、王永雄、彭金滿：〈地心論與日心論之爭〉，大學通識報第2期，p. 143-144:

哥白尼細節理論的複雜情況比起托勒密理論有過之而無不及：重要的一例是在《天球旋轉論》第三篇，地球環繞太陽的描述。在托勒密細節理論中，太陽直接環繞偏心的地球。哥白尼卻認為環繞太陽 S 的是神秘的動點 O ，以周轉圓環繞 O 的是第二神秘動點 O_E ，地球 E 環繞著這第二神秘動點 O_E 運行。（圖4-2）⁴⁷

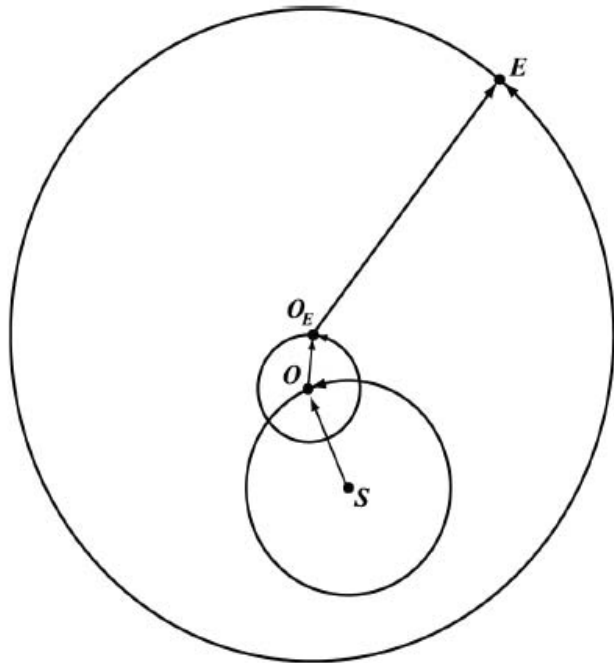


圖4-2 哥白尼細節理論的複雜性可見於地球繞日的模型
(大小不按比例)

'The preface to the *De Revolutionibus* opens with a forceful indictment of Ptolemaic astronomy for its inaccuracy, complexity, and inconsistency, yet before Copernicus' text closes, it has convicted itself of exactly the same shortcomings.' – T. Kuhn, *The Copernican Revolution*, p. 171.

庫恩的評論

在二十世紀中葉，美國科學哲學家庫恩說：⁴⁸

(哥白尼的) 整套理論臃腫不亞於托勒密理論。兩者都採用不止三十個圓，簡潔程度不相伯仲，兩者的準確度也軒輊難分。當哥白尼加了足夠的圓圈後，他臃腫的日心系統產生的答案像托勒密理論一樣準確，但並沒有產生更準確的答案。哥白尼並沒有(如他自己所宣)稱解決了行星的問題。

庫恩講得太過委婉。其實托勒密的細節理論採用了34個周轉圓，哥白尼細節理論起碼要加多7個周轉圓來解釋行星運動，而精確度反而倒退了。甚至哥白尼所標榜的，只是自己(大體)理論的美，而不是實用性。⁴⁹

為甚麼哥白尼的學說推動了科學革命？

哥白尼日心說的影響

- 動搖阿里斯多德力學及宇宙論，宗教神權
- 宇宙很大 → 很多太陽系、行星、甚至生物 (G. Bruno)
- 行星運動的準確觀測及計算(第谷Tycho、開普勒 Kepler)
- 地球以高速運行-為甚麼人停留地上? → 力學、萬有引力理論 (伽利略 Galileo、牛頓 Newton)
- 推動科學革命

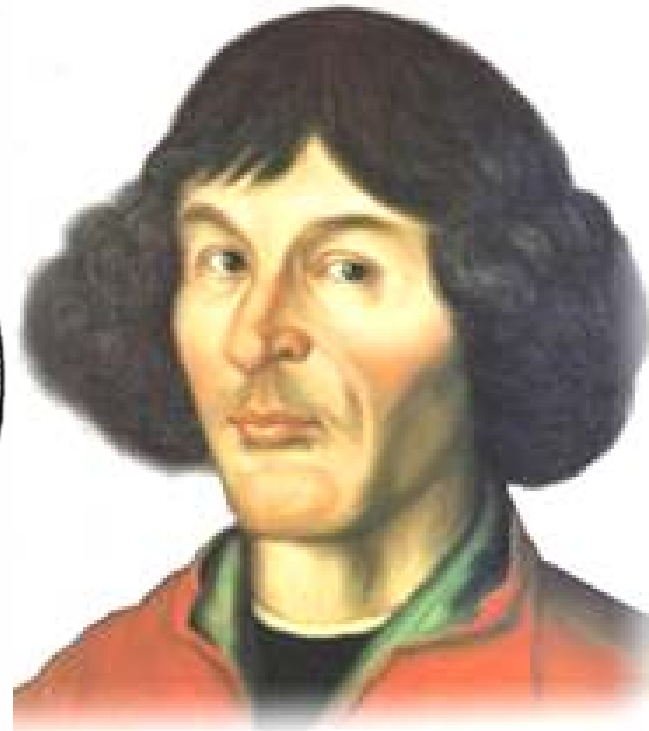
為甚麼哥白尼的學說推動了科學革命？

- 大大貶低人的地位，令人對自然謙卑
- 指出人類由日常生活經驗發展出的直覺之不可靠
- 亦展示理性思考的可能性
- 理性討論作為工具的示範
- 錯誤的重要性
- 求真 **vs.** 求善？
- 執着甚麼？放棄甚麼？

通識沙龍2009

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天體運行論

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