

## Literature

### 2. Textbooks on General Relativity

WEINBERG, S., 1972, *Gravitation and Cosmology*, New York: Wiley, 129€

Classical textbook on GR, still one of the best introductions. Nice section on classical cosmology.

SCHUTZ, B.F., 1985, *A First Course in General Relativity*, Cambridge: Cambridge Univ. Press, 45.90€

Nice and modern introduction to GR. The cosmology section is very short, though.

MISNER, C.W., THORNE, K.S. & WHEELER, J.A., 1973, *Gravitation*, San Francisco: Freeman, 104.90€

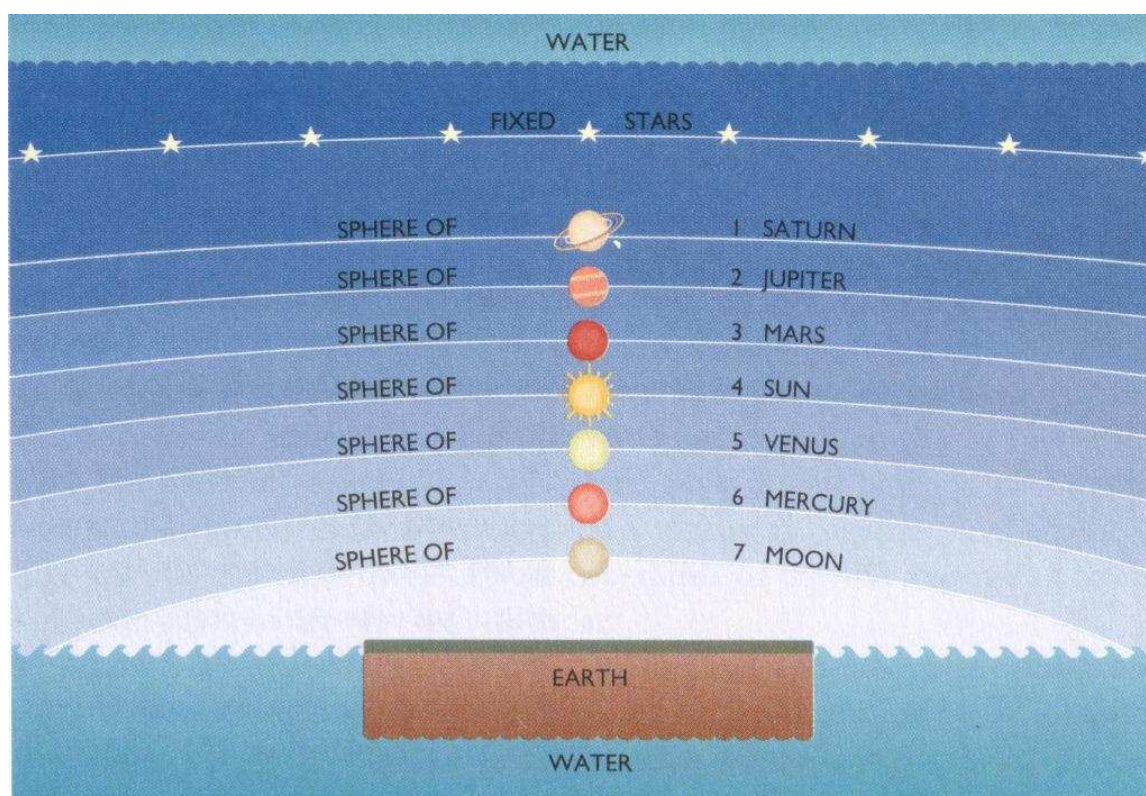
Commonly called MTW, this book is as heavy as the subject. . . Uses a weird notation. The cosmology section is outdated.

WALD, R.M., 1984, *General Relativity*, Chicago: Univ. Chicago Press (only antiquarian, ~\$40)

Modern introduction to GR for the mathematically inclined.

# *History*

# Babylon



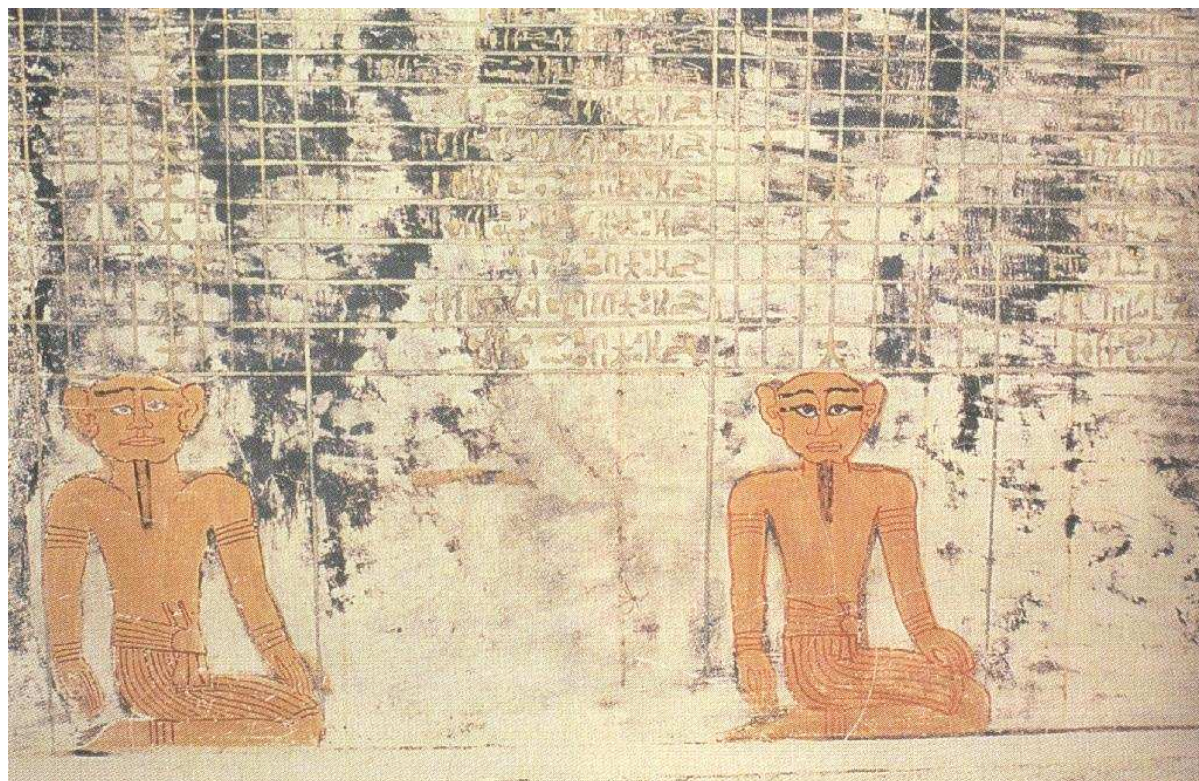
(Aveni, 1993, p. 13)

**Babylonian astronomy:** Earliest astronomy with influence on us:  $\sim 360$  d year  $\implies$  **sexagesimal system**, 24h day, ...

**Enuma Elish** myth ( $\sim 1100$ BC): Universe is place of battle between earth and sky, born from world parents.

Note similar myth in the Genesis...

# Egypt



(Aveni, 1993, p. 42)

Coffin lid showing two astronomers' assistants, 2000... 1500 BC; hieroglyphs list stars ("decans") whose rise defines the start of each hour of the night.

~2000 BC: 365 d calendar ( $12 \times 30$  d plus 5 d extra), fixed to Nile flood (heliacal rising of Sirius), star clocks.

*heliacal rising*: first appearance of star in eastern sky at dawn, after it has been hidden by the sun.

## Greek/Roman, I

**Early Greek astronomy:** folk tale astronomy (Hesiod, Weeks and Days), similar to Egypt.

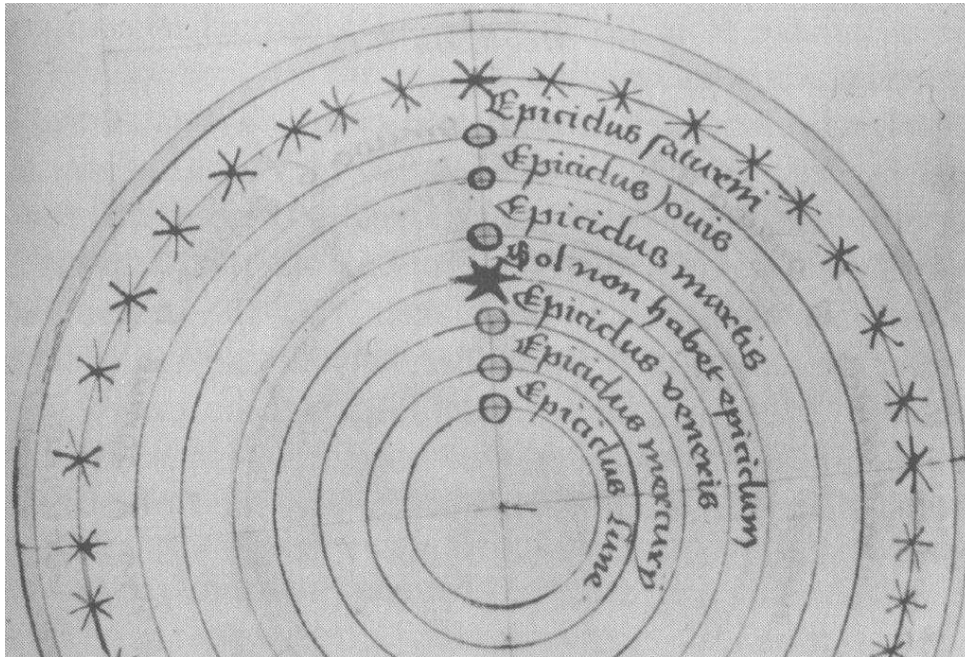
**Thales** (624–547 BC): Earth is flat, surrounded by water.

**Anaxagoras** (500–428 BC): Earth is flat, floats in nothingness, stars are far away, fixed on sphere rotating around us. Eclipses are due to shadow of Earth.

**Eudoxus** (408–355 BC): Geocentric model, planets affixed to concentric crystalline spheres, stars on outermost disk. **First real model for planetary motions!**

**Aristarchus** (310–230 BC): Determination of rel. distance to Moon and Sun: Moon is  $\sim 20\times$  closer.

## Greek/Roman, II



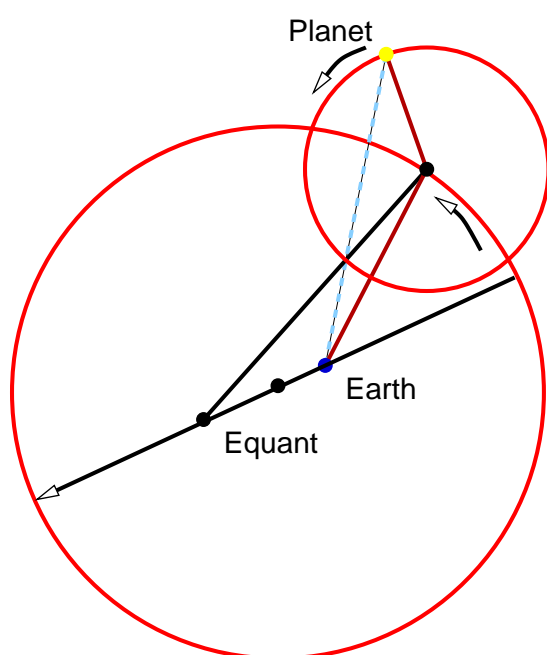
**Aristotle** (384–322 BC, *de caelo*): Refinement of Eudoxus model: add spheres to ensure smooth motion  $\implies$  Universe filled with crystalline spheres (nature abhors vacuum).  
 $\implies$  **Central philosophy until  $\sim$ 1450AD!**

**Hipparchus** (?? –  $\sim$ 127 BC): Refinement of geocentric Aristotelian model into tool to make **predictions**.

## Greek/Roman, III



(Aveni, 1993, p. 58)



**Ptolemaeus** (~140AD):  
*Syntaxis*, aka **Almagest**:  
 Refinement of Aristotelian  
 theory into model useable  
 for computations  $\implies$   
**Ptolemaic System.**

## Renaissance, I



**Nicolaus Copernicus** (1473–1543): Ptolemaic system is too complicated, a sun-centered system is more elegant: “In no other way do we perceive the clear harmonious linkage between the motions of the planets and the sizes of their orbs.”

Copernicus principle: The Earth is not at the center of the universe.



## Renaissance, II



(Gingerich, 1993, p. 165)

*De revolutionibus orbium coelestium libri vi*

## Renaissance, III



**Tycho Brahe** (1546–1601): Visual planetary positions of highest precision reveal flaws in Ptolemaic positions  $\implies$  Refinement of Ptolemaic system into a semi-Copernican form.

## Renaissance, IV



**Johannes Kepler** (1571–1630): Planets orbit on **ellipses** around sun, not on **circles**, laws of motion.

**Galileo Galilei** (1564–1642): Moons of Jupiter (Kepler  $\implies$  similar to heliocentric model!)



F. Curtus Bon. Incid.

Übersetzung der lateinischen Texte auf dem Stich von Ricolti (von oben nach unten):

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Dies diei eructat uerbu...	Der Tag des Tags (=der jüngste Tag) wirft das Wort von sich <i>oder</i> Der Tag der Tage speit das Wort aus.
... et nox nocti indicat scientiam	Und eine Nacht teilt der anderen das Wissen mit <i>oder</i> Die Nacht der Nächte zeigt die Wissenschaft
Finger an Hand Gottes: Numerus, Mensura, Pondus	Weisheit Salomos (Apokryphe Schriften des Alten Testaments, Kapitel 11,21): "Aber du [Gott] hast alles nach <i>Maß, Zahl</i> und <i>Gewicht</i> geordnet" – Schöpfungstheologisch/kosmologische Kernstelle der Bibel
Videbo Caelos tuos, opera digitor tuor	Ich werde deine Himmel erkennen können, ich verteidige sehr würdig deine Werke <i>oder</i> ich werde deine Himmel sehen...
Non Inclinabitur in saeculum saeculi	Er wird mir in Ewigkeit keine andere (falsche) Richtung geben werden.
Erigo dum corrigar	Ich werde aufgerichtet/ermutigt werden indem ich verbessert werde
Ponderibus librata suis	Mit ihren Gewichten wird sie kräftig geschwungen <i>oder</i> Mit seinen Gewichten im Gleichgewicht gehalten.

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Mit 10000fachem Dank an Papa Deetjen und Sohn, Marcus Kirsch, Eckart und Irene Goehler, und die Espressorunde!!!!

Weitere Übersetzungsvorschläge werden dankend entgegengenommen.

## Newton



(Newton, 1730)

**Isaac Newton** (1642–1727): Newton's laws,  
Physical cause for shape of orbits is gravitation  
(*De Philosophiae Naturalis Principia  
Mathematica*, 1687).

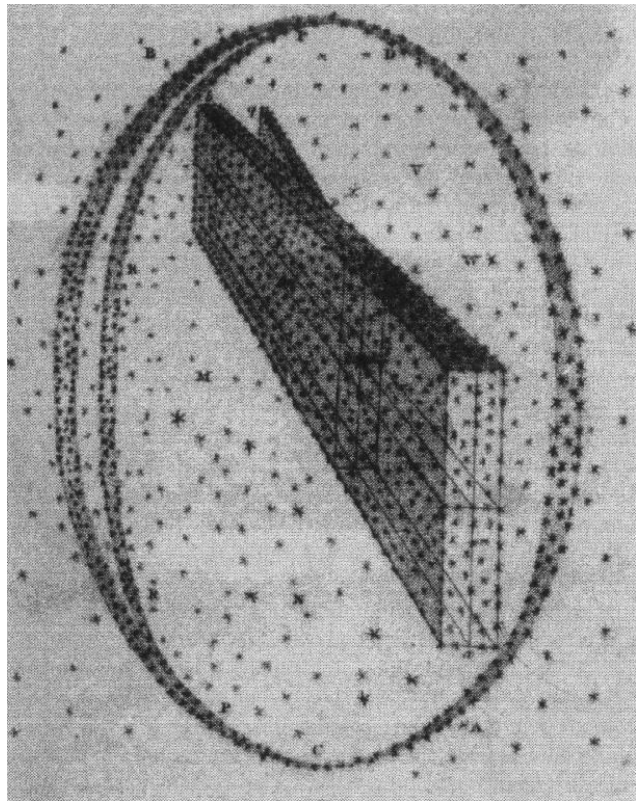
⇒ Begin of **modern cosmology**.

## Modern Cosmology

**Galileo:** Milky way consists of stars.

**Newton:** Stars are distant suns

**William Herschel**  
(1738–1822): Milky Way is a flattened disk of stars, sun is at center.



**Friedrich Bessel** (1784–1846): Distance to 61 Cyg (1838), positions of 50000 stars

**Immanuel Kant:** “Nebulae are galaxies” (disputed until the 1910s).

**John Herschel** (1792–1871): General Catalogue of Galaxies (1864, 5079 Objects)

**Johan Dreyer** (1852–1926): NGC+IC (15000 Objects)

## Modern Cosmology



**Albert Einstein** (1879–1955): Theory of gravitation, applicability of theory to evolution of the universe as a whole.



## Modern Cosmology



(Christianson, 1995, p. 165)

**Edwin Hubble** (1889–1953): **Universe is expanding**, realization of galaxies as being outside of the milky way: **extragalactic astronomy**

Bibliography

Aveni, A. F., 1993, *Ancient Astronomers*, (Washington, D.C.: Smithsonian Books)

Christianson, G. E., 1995, *Edwin Hubble – Mariner of the Nebulae*, Farrar, Straus and Giroux)

Gingerich, O., 1993, *The Eye of Heaven – Ptolemy, Copernicus, Kepler*, (New York: American Institute of Physics)

Newton, I., 1730, *Opticks*, Vol. 4th, (London: William Innys), reprint: Dover Publications, 1952