Local Horizon and Sundials

本地地平圈与日晷

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Goals

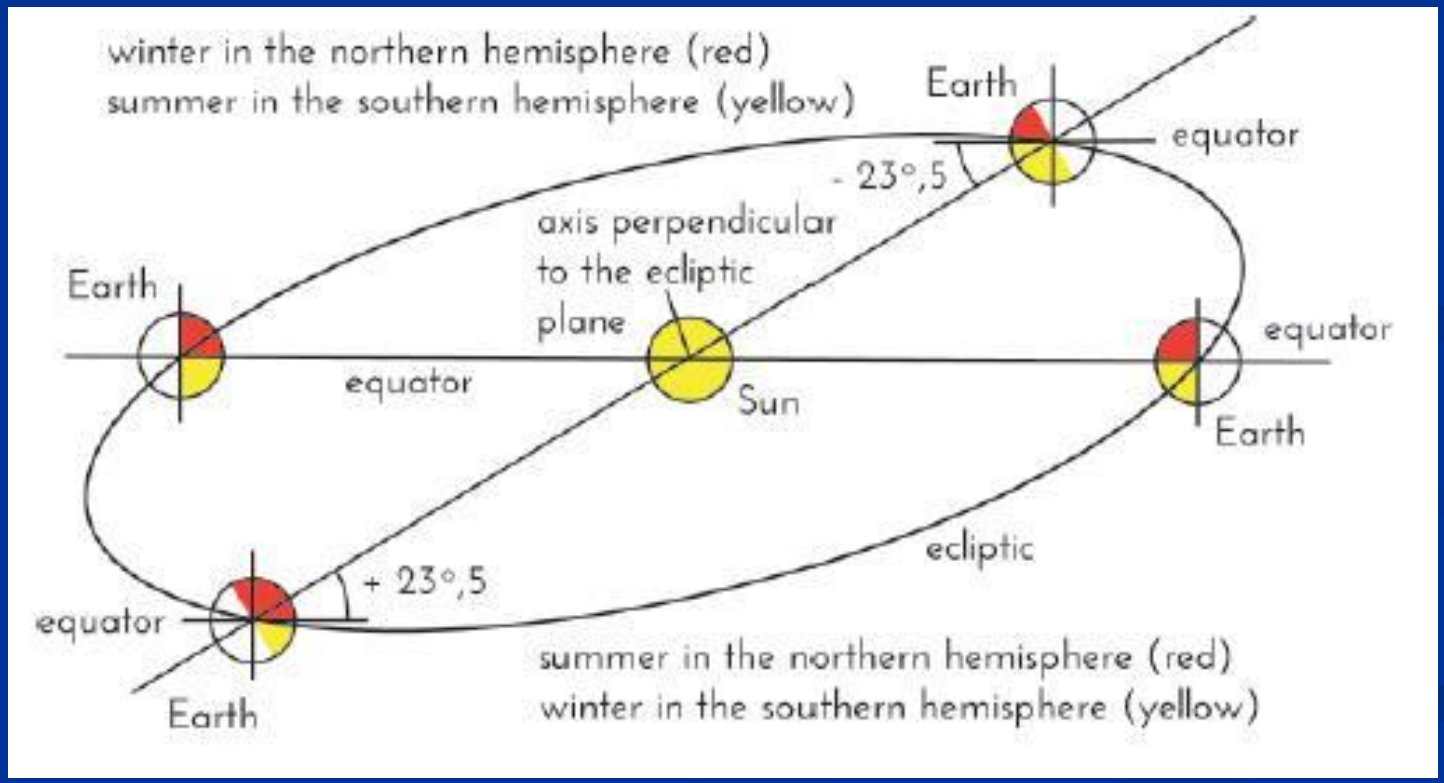
- Understand the diurnal movement of the Sun
- 理解太阳的周日视运动
- Understand the annual movement of the Sun
- 理解太阳的周年视运动
- Understand the movement of the celestial sphere
- 理解天球运动
- Understand the construction of sundials
- 理解日晷的构造

The Earth rotates and moves

地球的自转与运动

rotation (day / night)自转（白天/晚上）

orbital position (seasons)在轨位置（季节）



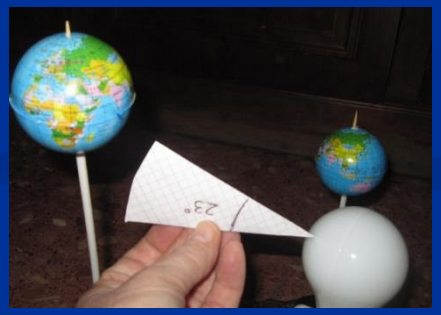
Activity 1: Four Earth spheres with the Sun (a lamp) in the middle.

活动1：四个地球仪围绕中间的太阳（灯泡）.

The line from the centre of the Sun to the centre of the Earth makes a 23.5° angle with the ground

(which represents the plane of the Equator).

日地（灯泡和地球仪）中心连线与地面的夹角为23. 5°（地面代表赤道面）



Winter in the Northern Hemisphere
北半球的冬天

Summer in the Southern Hemisphere
南半球的夏天

Summer in the Northern Hemisphere
北半球的夏天

Winter in the Southern Hemisphere
南半球的冬天

Activity 2: Parallel Earth

活动2： 平行地球

A spotlight illuminates two spheres in the same way and produces the same areas of light and shadow

同一个点光源从相同方向照亮两个不同球体，结果在球体上产生同样的明暗区域。

Activity 2: Parallel Earth

活动2：模拟地球

* Remove the globe from its mounting, take it outside and stand it on a glass

* 把地球仪从底座上拿下来，放在室外的玻璃杯上。

* Carefully orientate its rotational axis with a compass

* 用指南针仔细校准它的自转轴指向。

* Turn it so our location is at the top

* 转动地球仪，使我们的所在位置处于顶部。

Activity 2: Parallel Earth

活动2：模拟地球

Place:

定位

* a doll indicating our position

* 玩偶代表我们的所在地。

* pieces of clay to mark the light / shadow line (it advances with time)

* 用小块黏土标识出明暗交界线。（该线位置随时间变化而改变）

* pieces of toothpick to create shadows to study

* 插上牙签，观察牙签的阴影。

Activity 2: Parallel Earth

活动2：模拟地球

* The North Pole is on the sunny side so it is summer in the Northern Hemisphere (the midnight sun)

* 北极位于被太阳照亮的一面，所以此时北半球是夏天(午夜太阳)。

* The South Pole is in shadow and therefore in the Southern Hemisphere it is winter

* 南极位于阴影中，所以此时南半球是冬天。

Activity 2: Parallel Earth

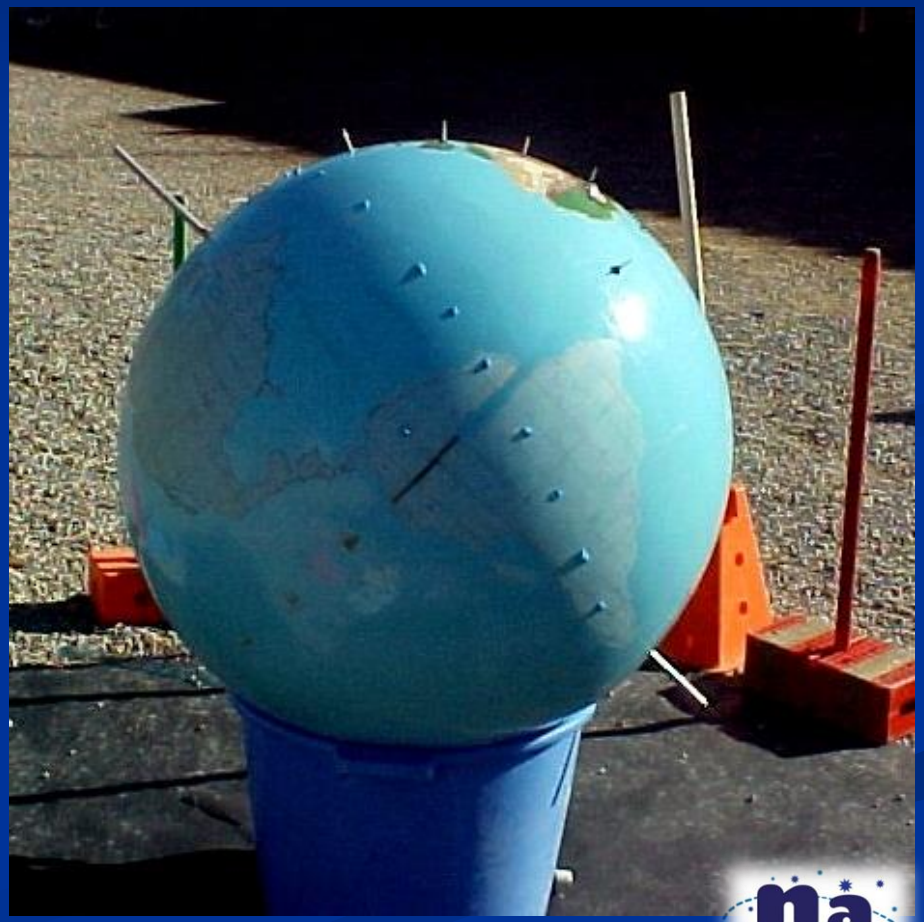
活动2：模拟地球

* The North Pole is within the area at darkness, so it is in the Northern hemisphere's winter.

* 北极位于阴影中，所以此时北半球是冬天。

* South Pole is illuminated and so it is summer in the Southern hemisphere.

* 南极被照亮，所以此时南半球是夏天。



Activity 2: Parallel Earth

活动2：模拟地球

When the day / night shadow line passes through both poles, it is the first day of spring or the first day of autumn.

昼夜分界线同时通过南北极点的这一天是春天或者秋天的第一天。

Activity 2: Parallel Earth

活动2：模拟地球

North H. summer
北半球，夏天

South H. winter
南半球，冬天

North H. equinoxes
北半球，春/秋分

South H. equinoxes
南半球，春/秋分

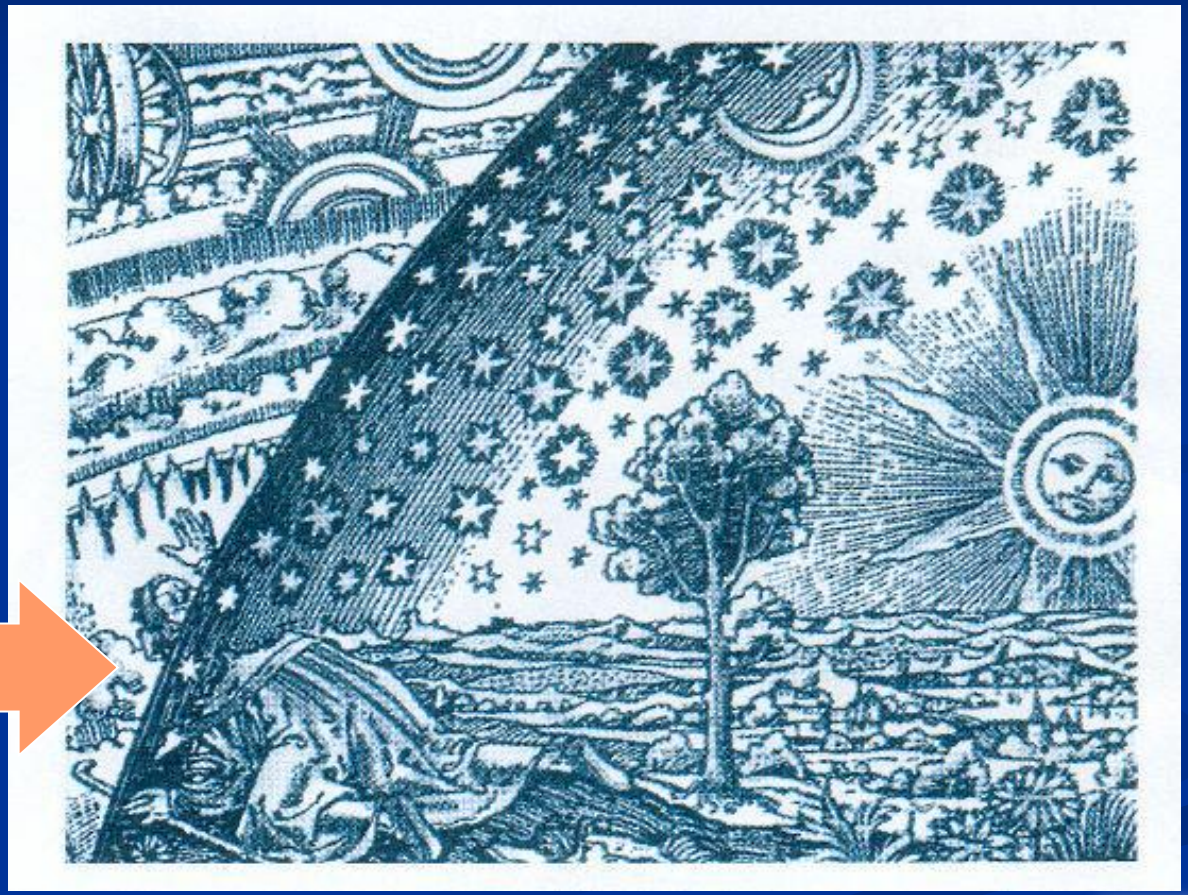
North H. Winter
北半球，冬天

South H. Summer
南半球，夏天

Rotation and celestial movements of day and night

自转与昼夜天体运行

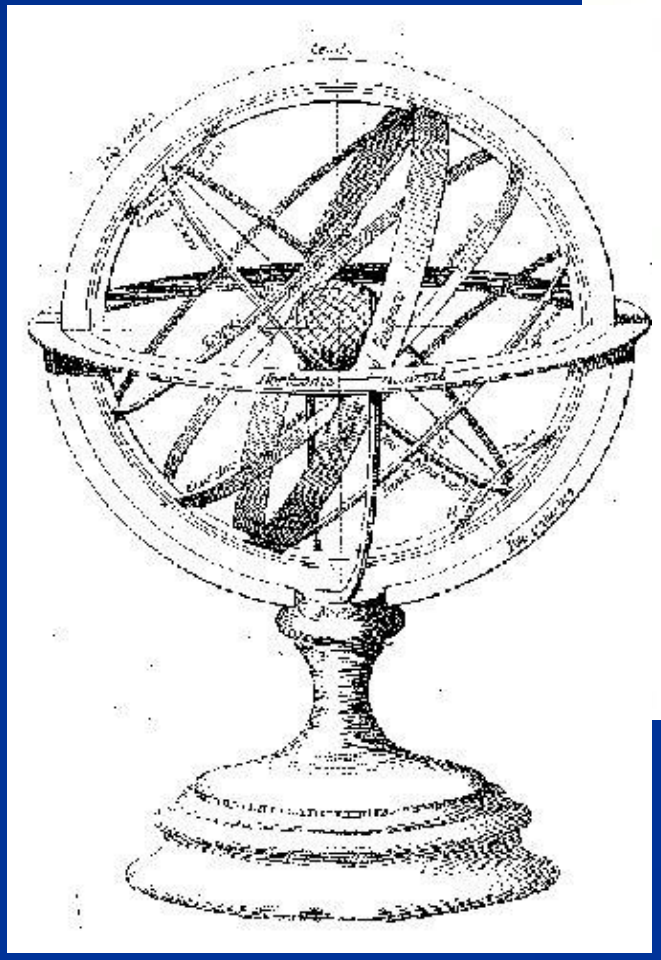
- Not the same when seen from inside and outside

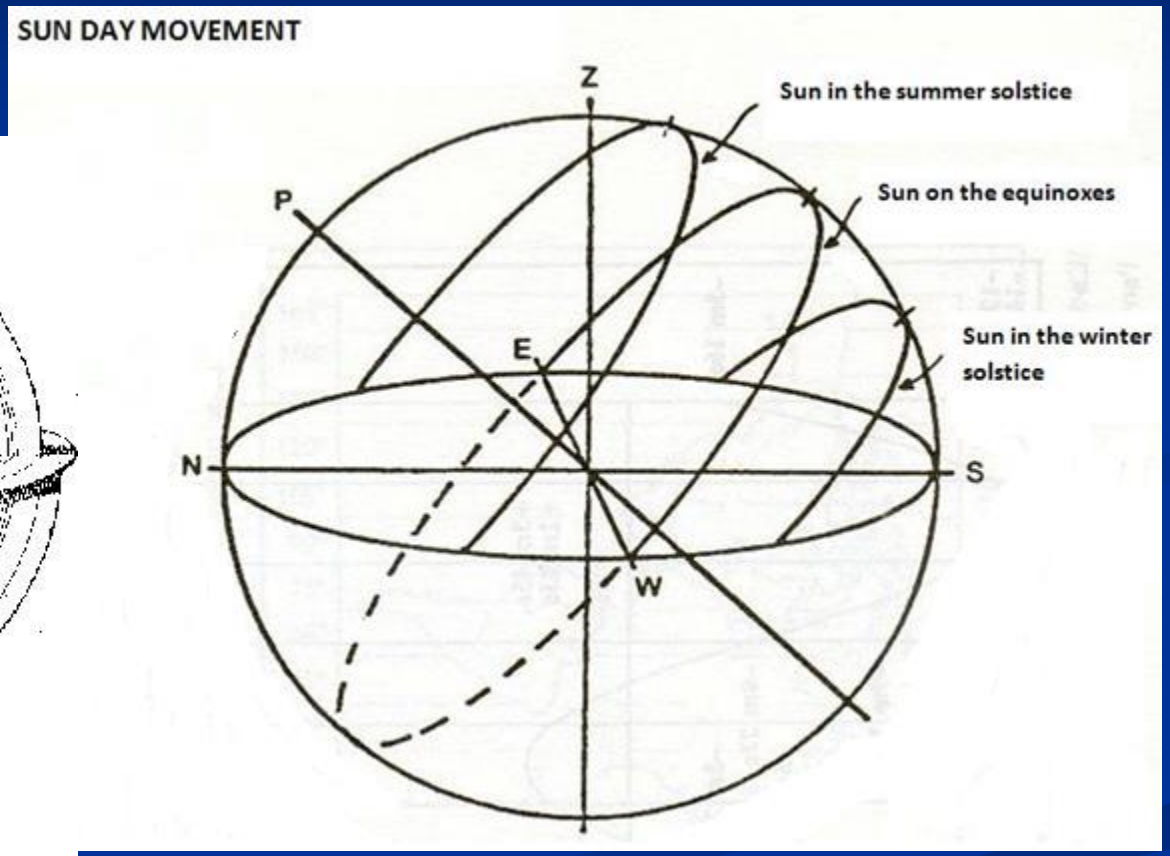


- 从天球的内部和外部看是不同的。

Celestial sphere "from outside”

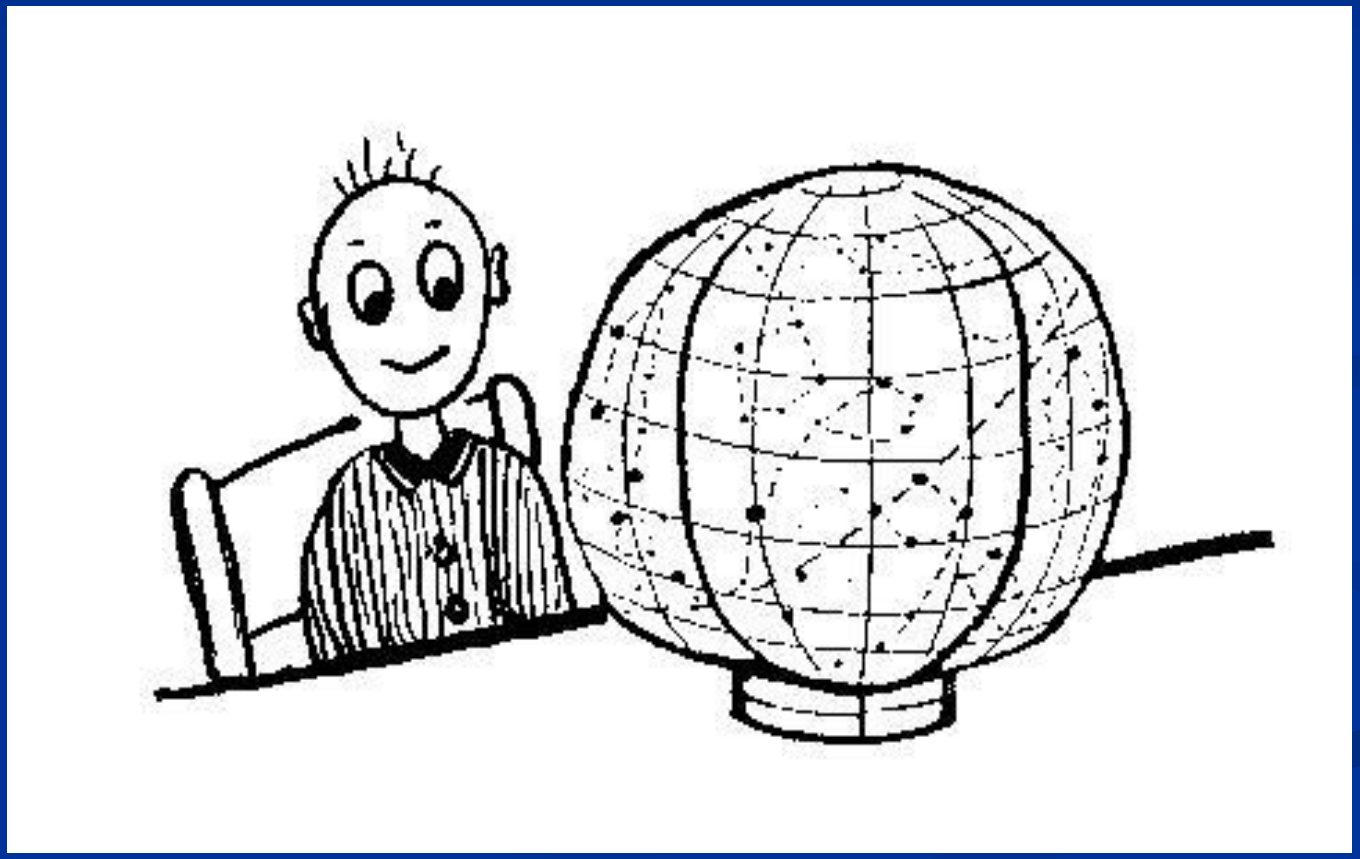
“从外面”看天球





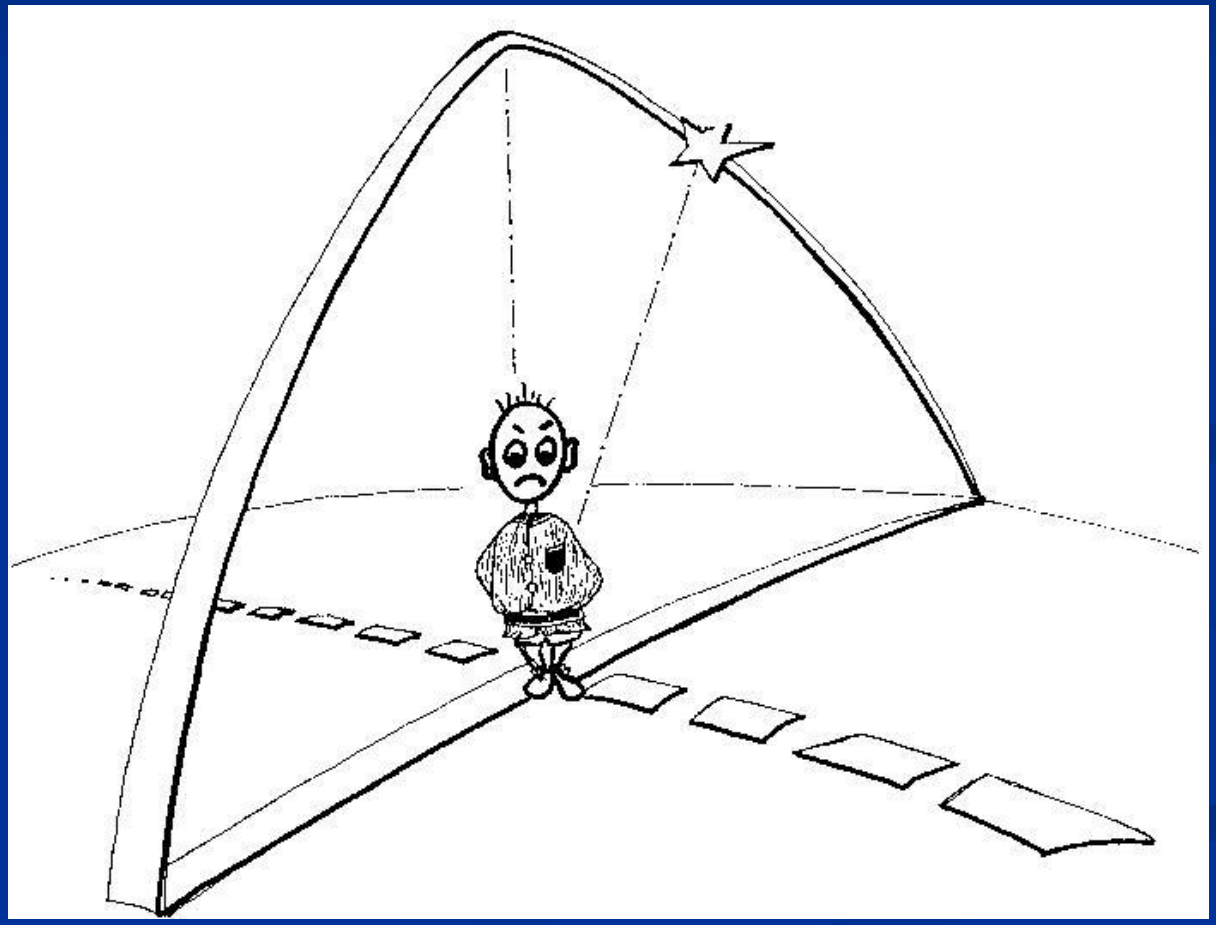
… it seems that everything is understood

…看上去一切都清楚明白



… but after class, … he is disconcerted

但下课之后，…他就费解了



All schools have an "Astronomy Laboratory“

所有学校都有
“天文实验室”

- They have a playground or school yard
- 学校都有操场或者院子
- They have the sky above
- 头顶都有天空
- They have clear days and nights
- 有着分明的白天和黑夜
- THESE MUST BE USED!
- 务必物尽其用

Activity 3: We will build a model of the horizon visible from school

活动3：我们来做一个在学校看到的地平景象模型

Begin by photographing all round your location

首先，我们拍摄当地的环景照片。

- local horizon
  - 本地地平圈

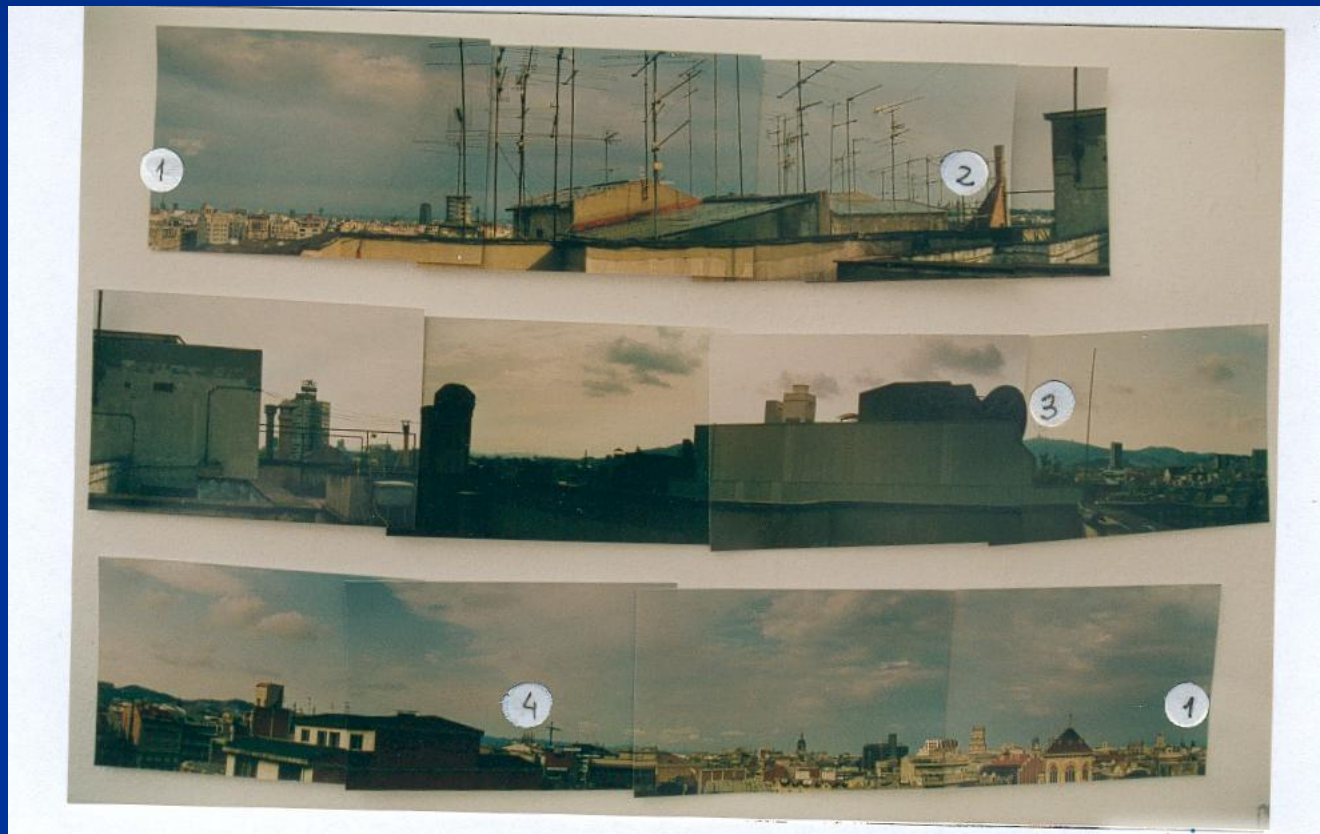
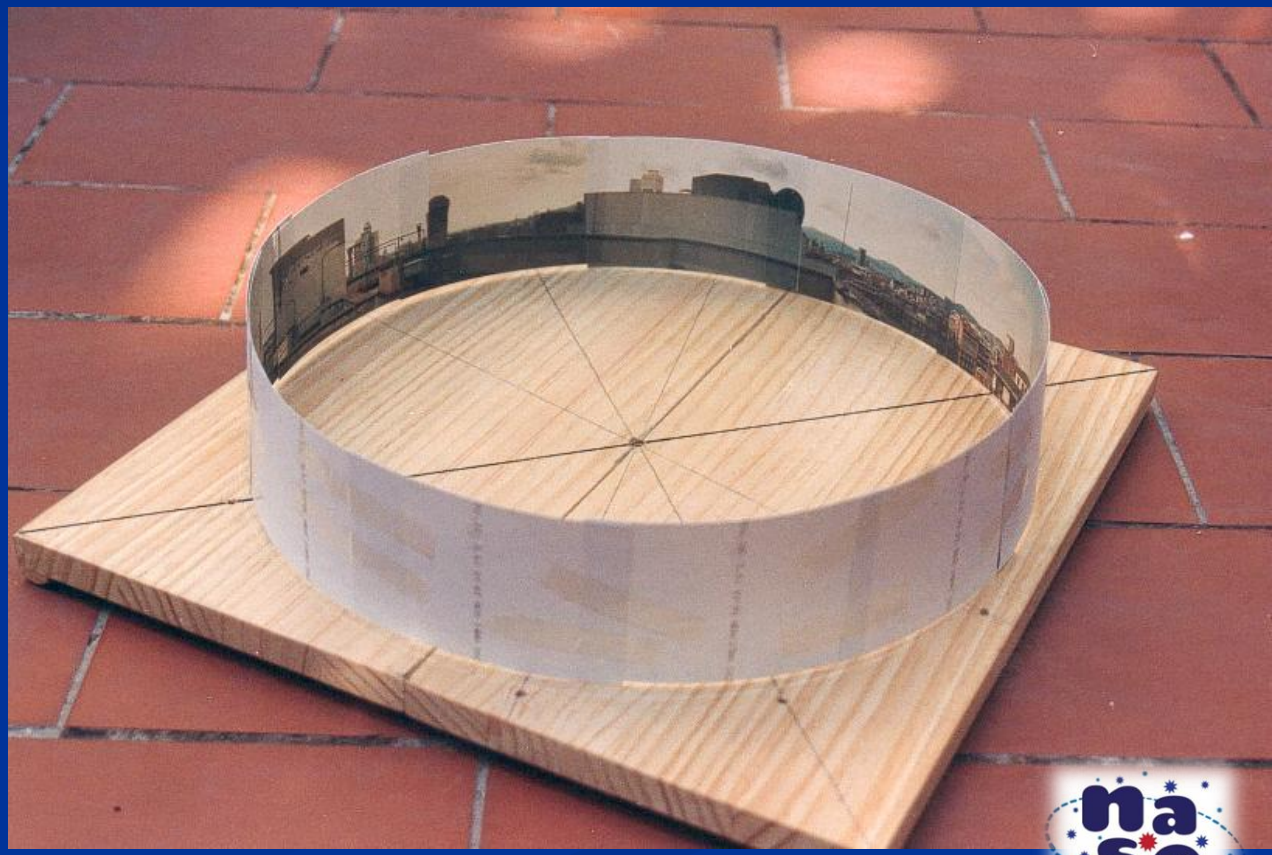


Figure 1: *Zona del horizonte fotografiada en Barcelona.*
1 Catedral, 2 Montjuic, 3 Tibidabo,
4 Sagrada Familia, 1 Catedral.

Let's glue the photos together on a supporting platform

把环景照片粘接起来，固定在一个平台上。

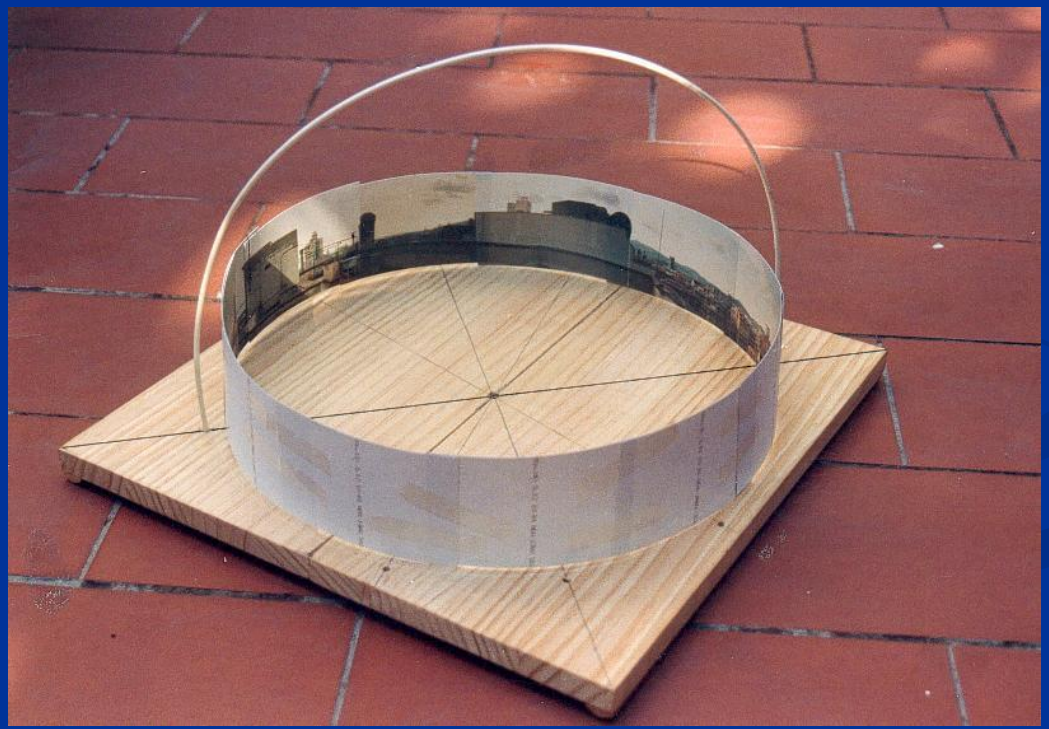
- local horizon
  - 本地地平圈



… we must adjust the photographed horizon to align it with the real horizon

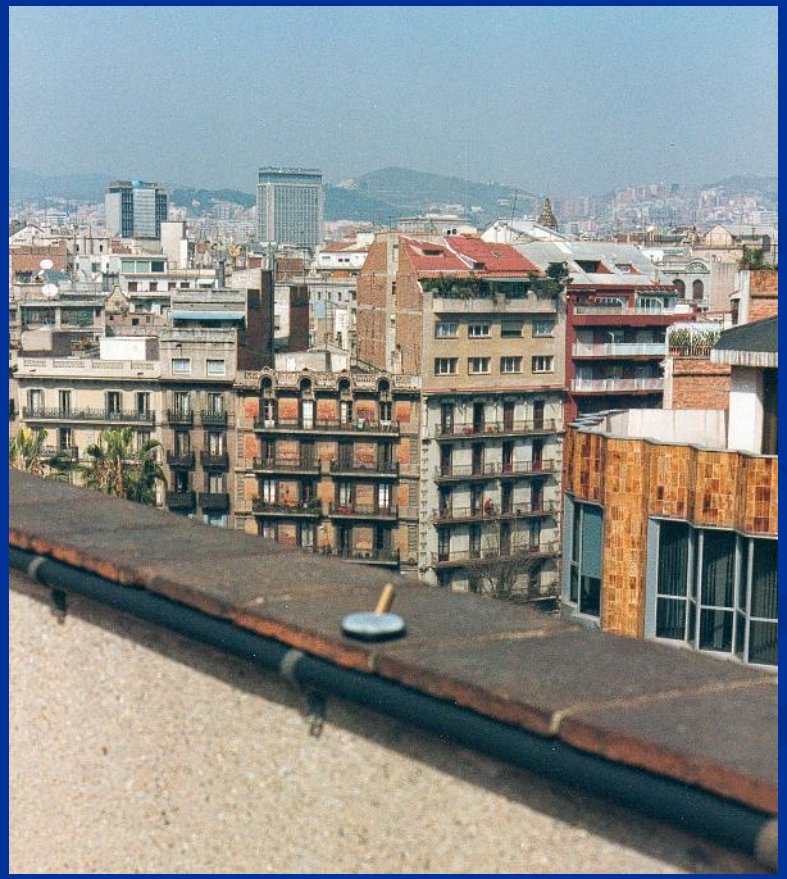
…我们需要将照片中的地平线与真实的地平线进行校准

- The N - S line and local meridian
- 南北连线与本地子午线



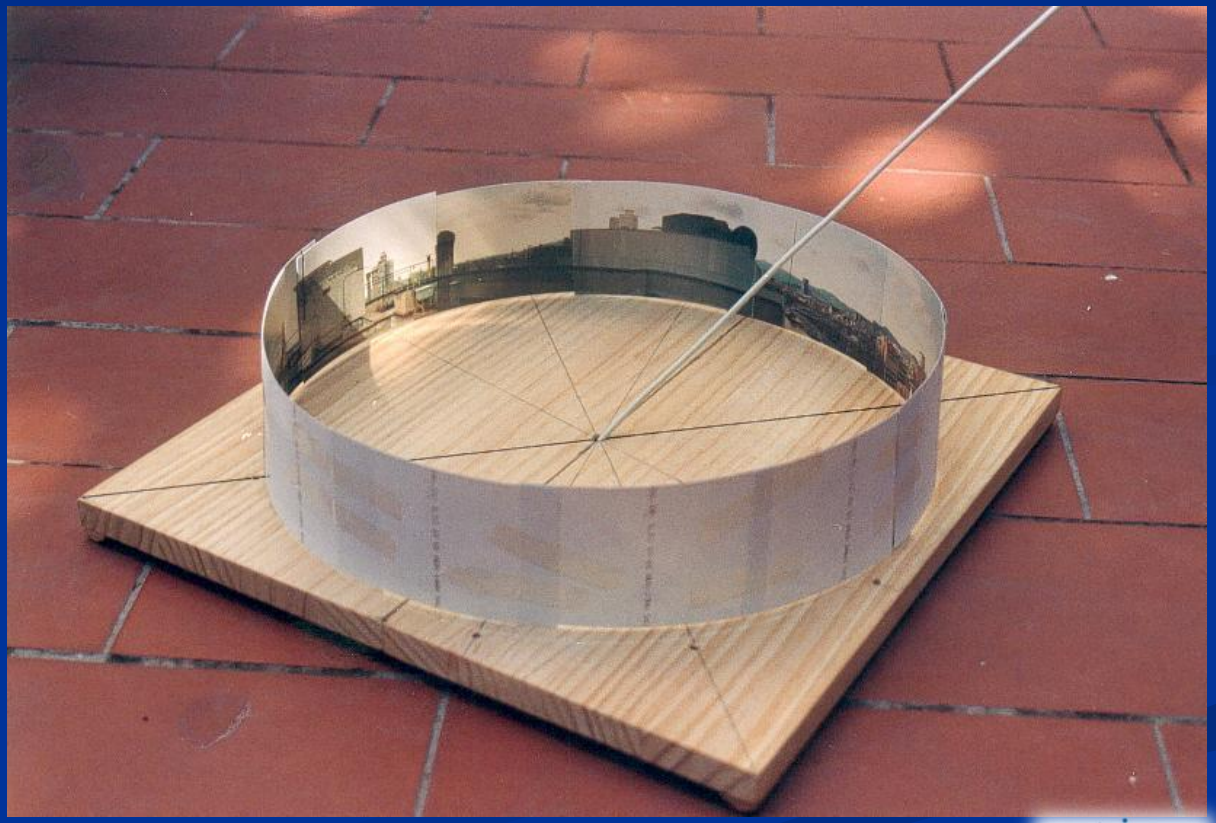
To position the model we can use the compass direction, or better, we can use the projection of the pole above the horizon

我们可以利用指南针为模型定位
另一种更好的方法是采用地平线上极点的投影



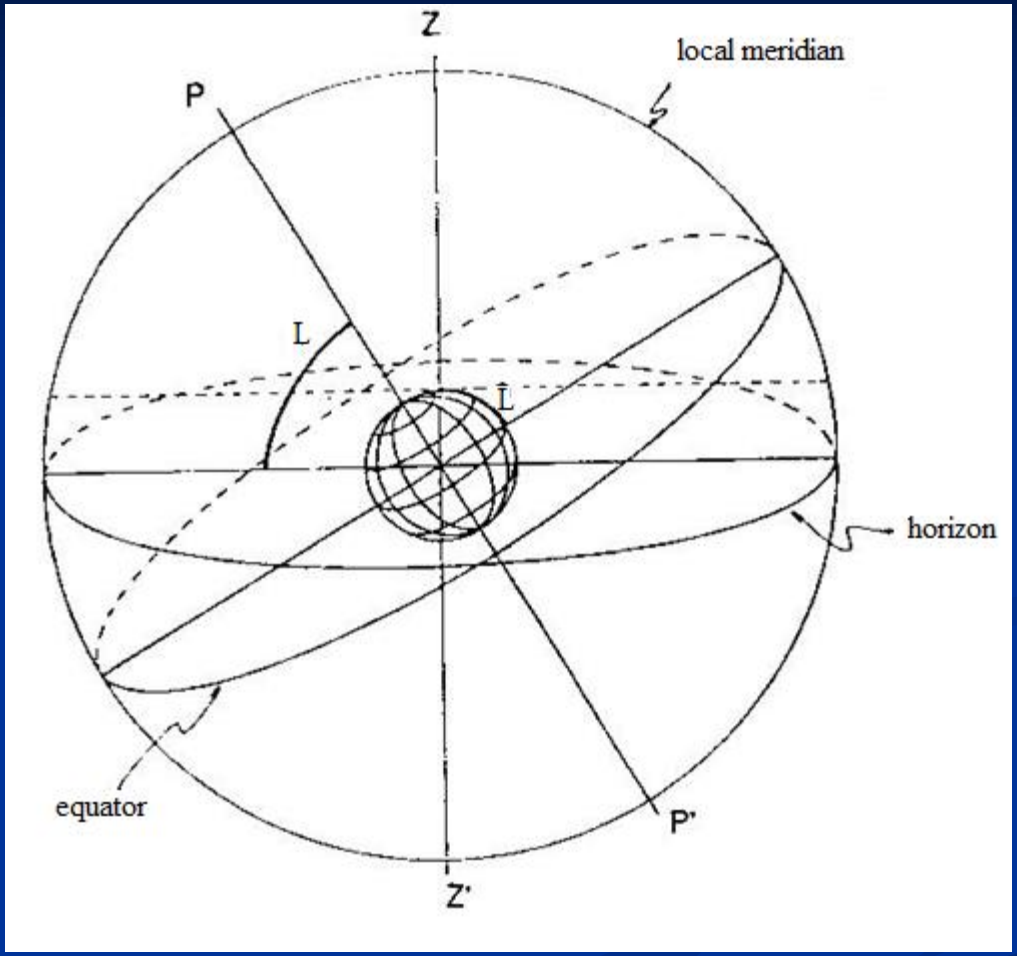
Introducing the Earth's rotation
引入地球的自转轴

- axis of the Earth
- 地轴



The altitude of the pole is equal to your latitude

极点的地平高度等于你的纬度

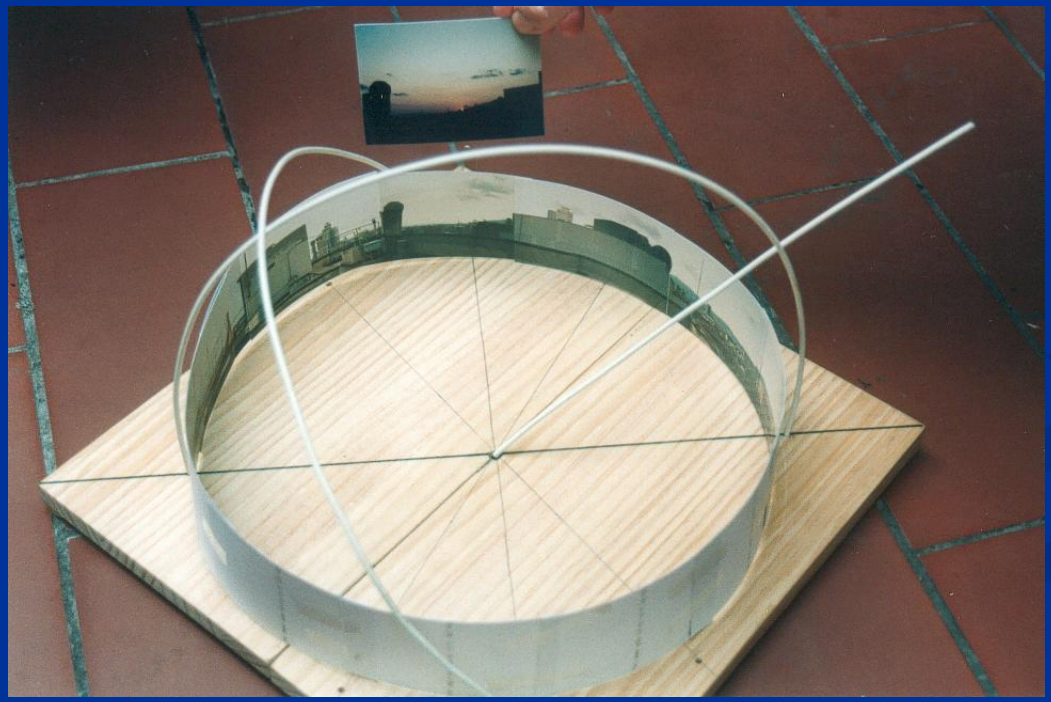


Indicate the apparent path of the sun on the first day of spring or autumn

标明太阳在春或秋季首日的运行轨迹

- Use the Sunrise or Sunset photos

  采用日出或日落的照片



Movement due to Earth's rotation:

地球自转造成的视运动：

Note the angle of the Sun's path

记录太阳视运动轨迹的角度

- Day - several images near sunset
- 白天——一组日落的照片

Movement due to Earth's rotation:

地球自转造成的视运动：

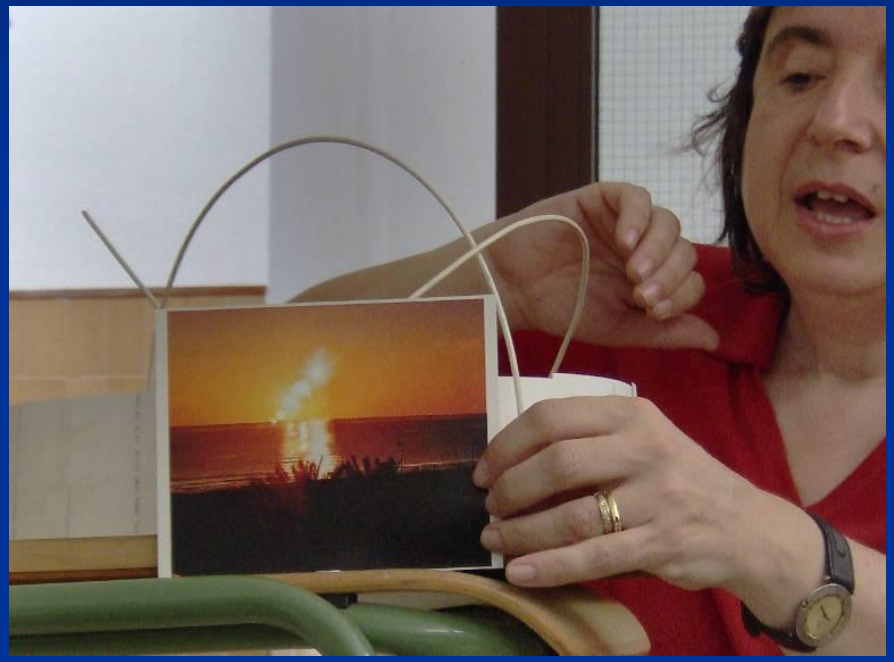
Note the angle of the star trails

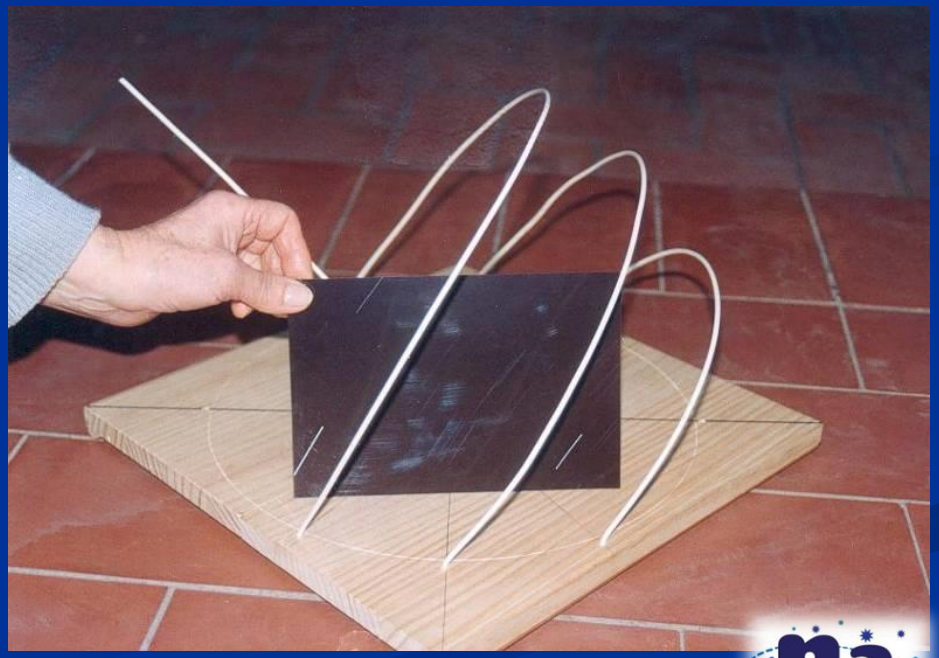
记录恒星视运动轨迹的角度

- Night – a time exposure of the stars
  - 夜晚——恒星长时间曝光相片

Rotational movement in the model

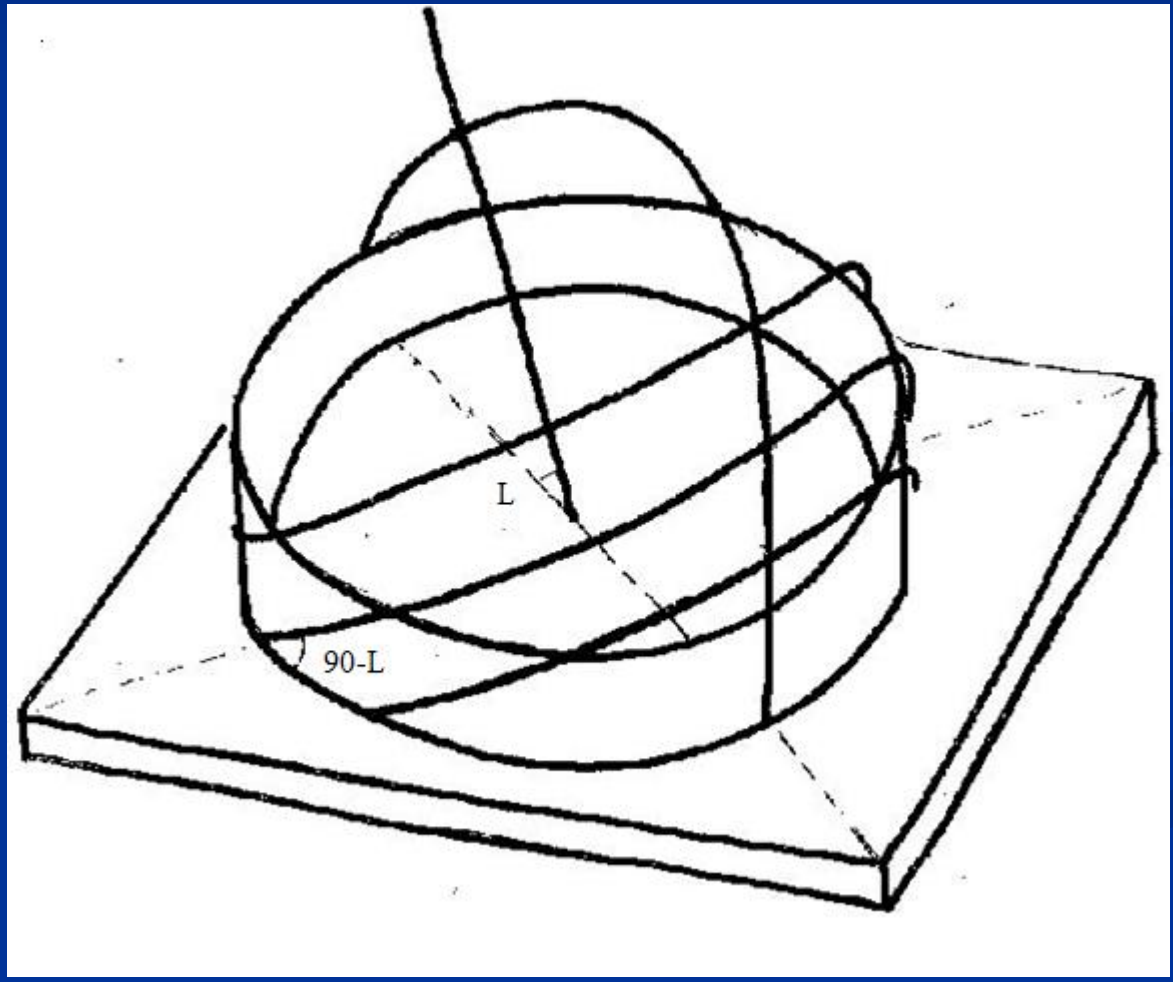
模型中的自转运动





The inclination of the Sun's apparent path and of the star trails depend on latitude

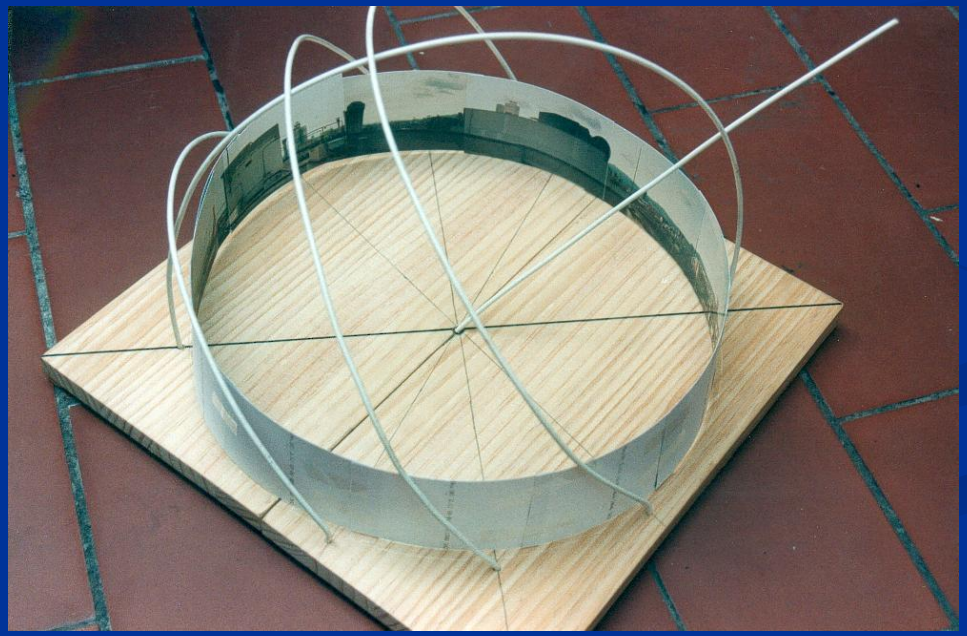
太阳和恒星轨迹的倾角取决于当地纬度



Solar paths on first day of each season (note the different durations)

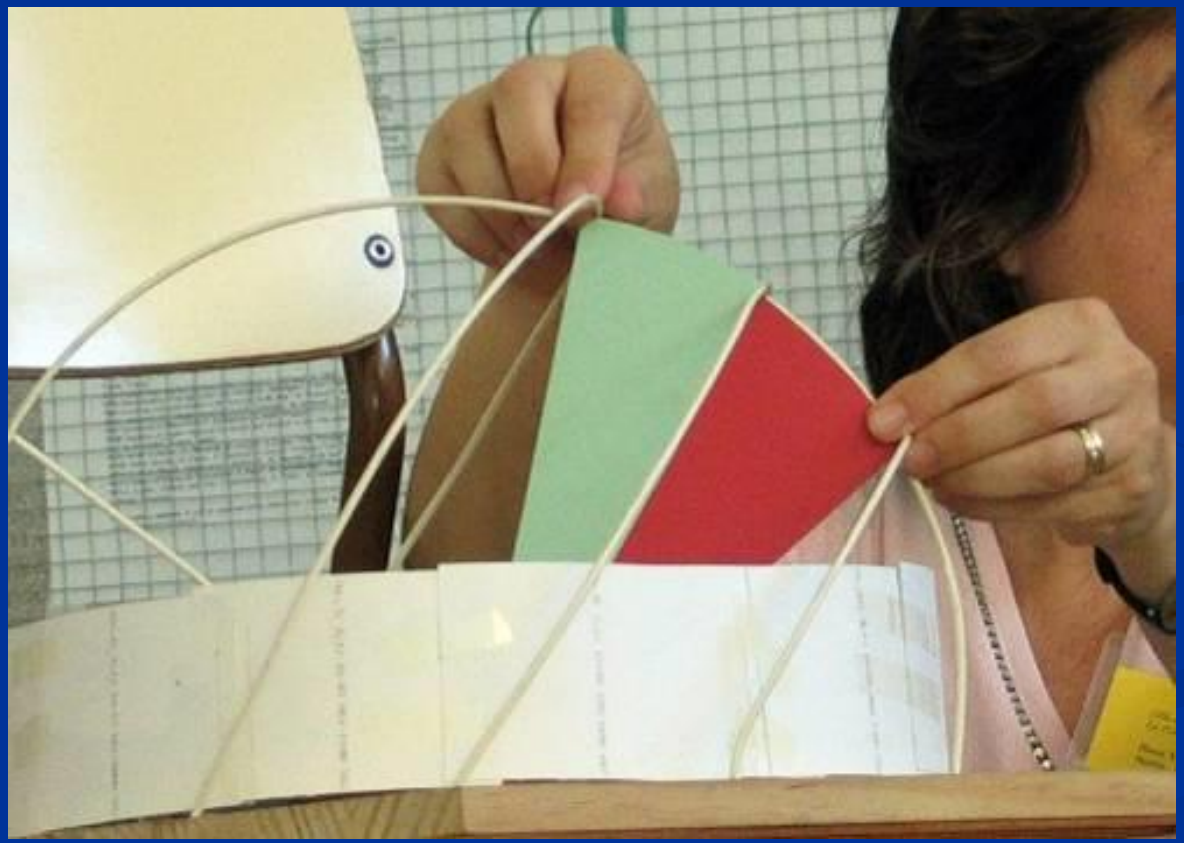
四季首日的太阳轨迹（注意不同的持续时间）

- Summer Solstice 夏至
- Autumnal / Vernal Equinox 秋分/春分
- Winter Solstice 冬至



Orbital motion leads to the seasonal positions

公转产生四季更迭



- Summer 夏
- Spring 春/ Autumn秋
- Winter冬

- Angle between equator and Tropic of Cancer or Tropic of Capricorn = 23.5 º
- 赤道与南/北回归线之间的角度是23. 5 º

The Earth's orbital motion leads to the change of the position of sunsets every day

地球公转导致了每天日落位置的变化

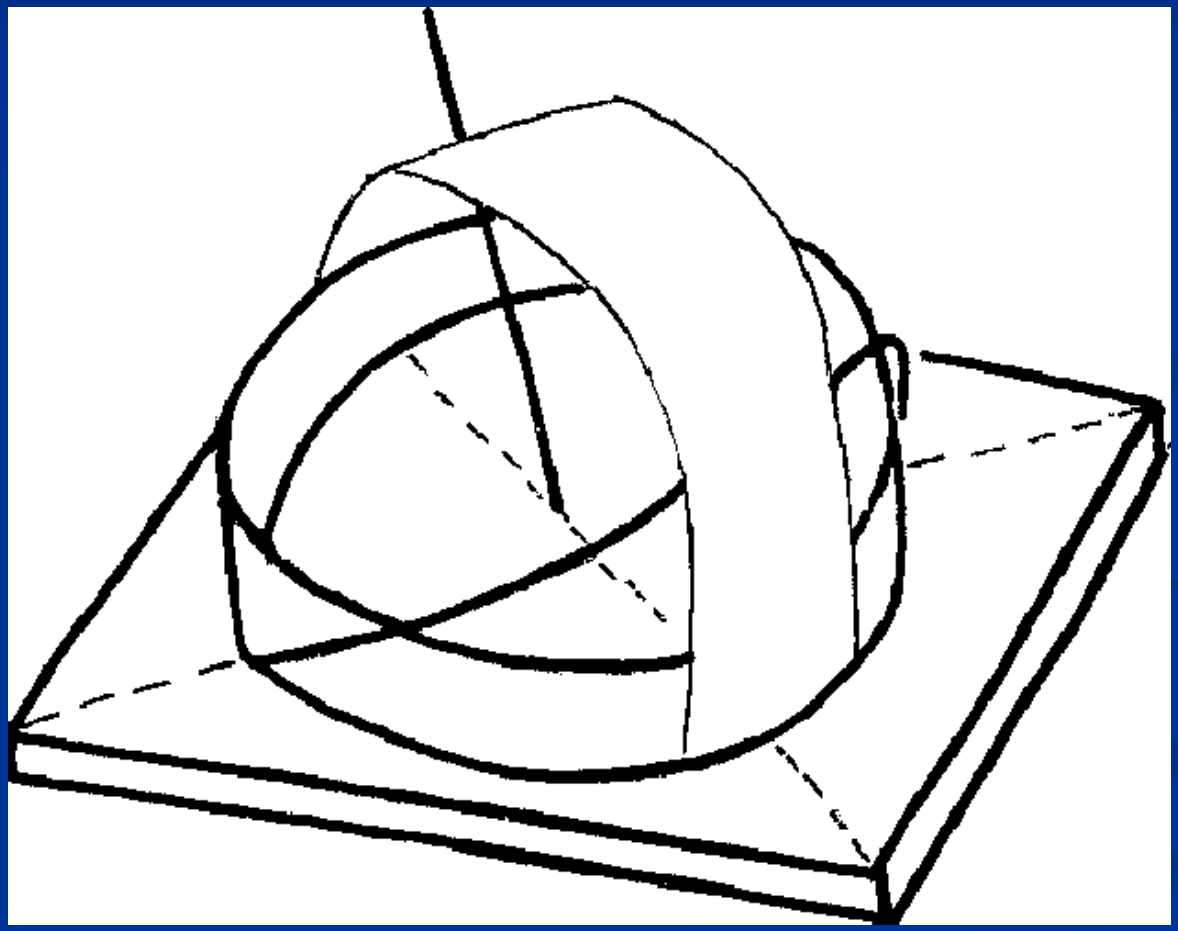
- 3 sunsets:
- Winter – Spring or Autumn – Summer
  - 3个日落点：冬季——春季或秋季——夏季

The Earth's orbital motion leads to the change of the position of sunrises every day

地球的轨道运动导致每天日出的位置发生变化

Viewing the "meridian" in the model

观察模型中的“子午线”



…around the pole – circles

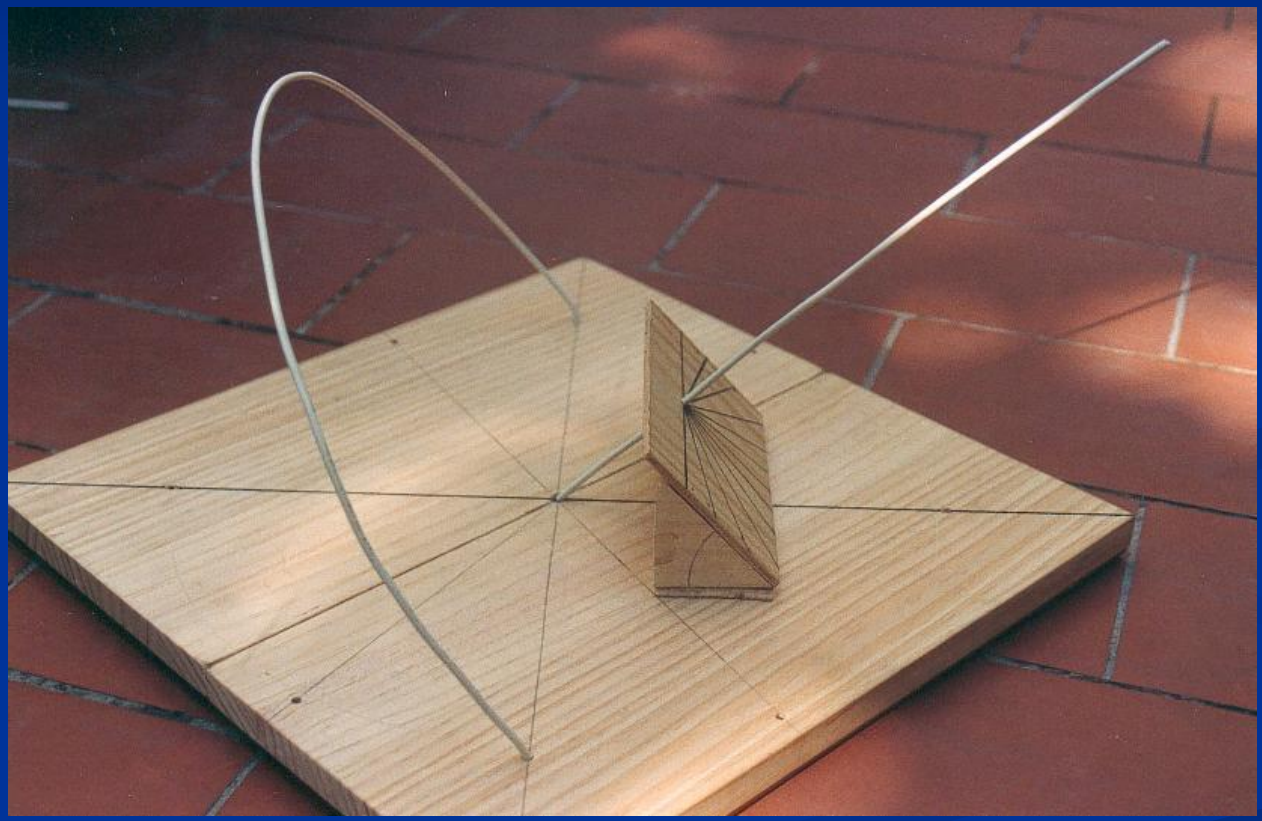
. . . 极地附近：绕极“恒显”星

…near the equator the paths change from concave to convex

…赤道附近，轨迹从凹线变成凸线

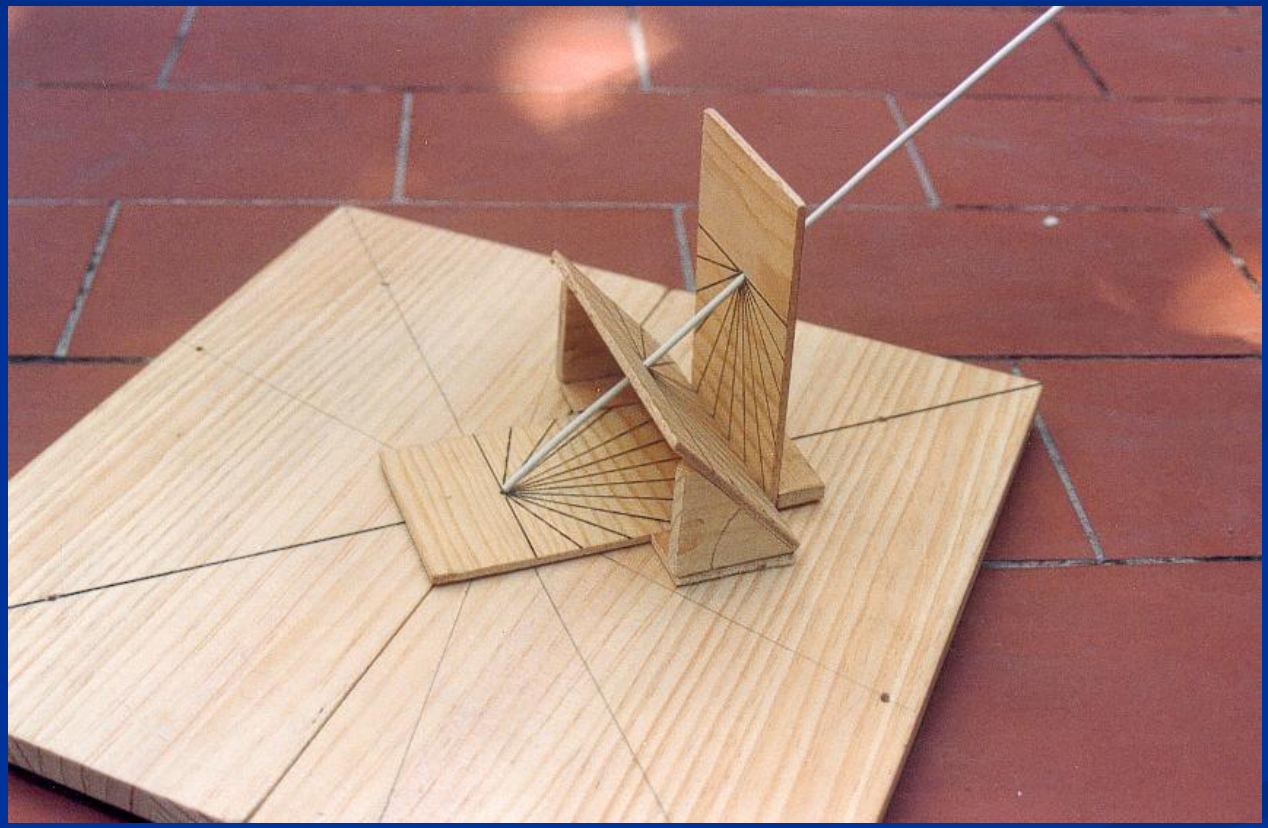
…the model is no more than an Equatorial Sundial!

…模型不过是个赤道式日晷！



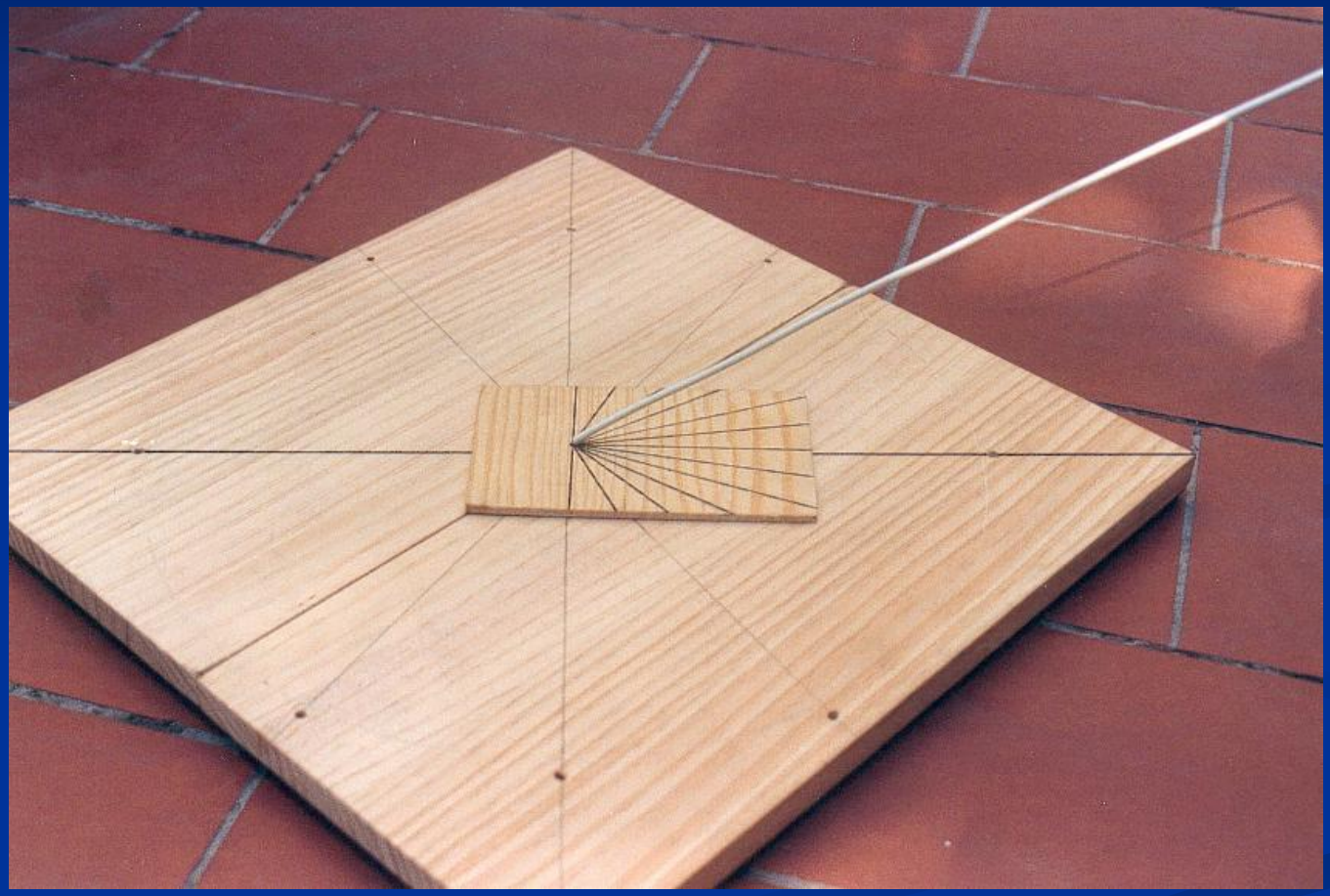
…other sundials can be made from the equatorial one

…由此我们还可以制作其它日晷



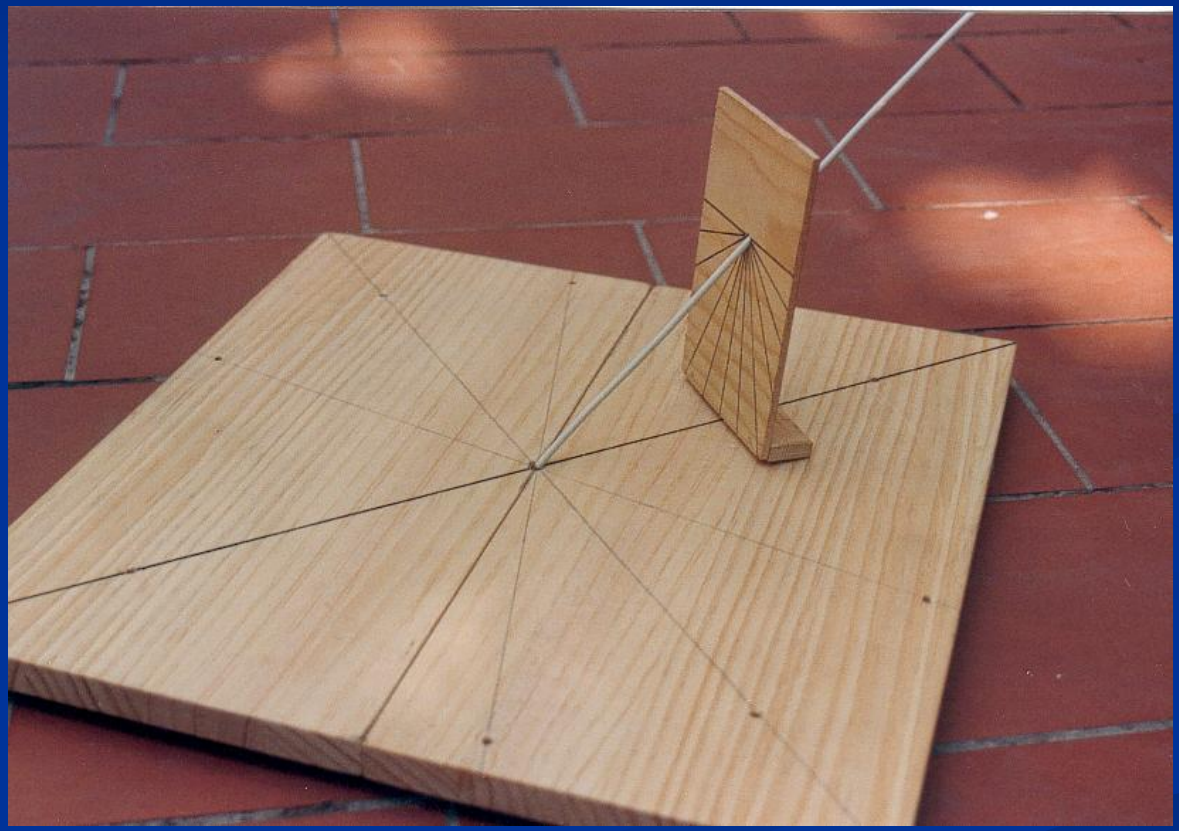
… the horizontal sundial

地平式日晷



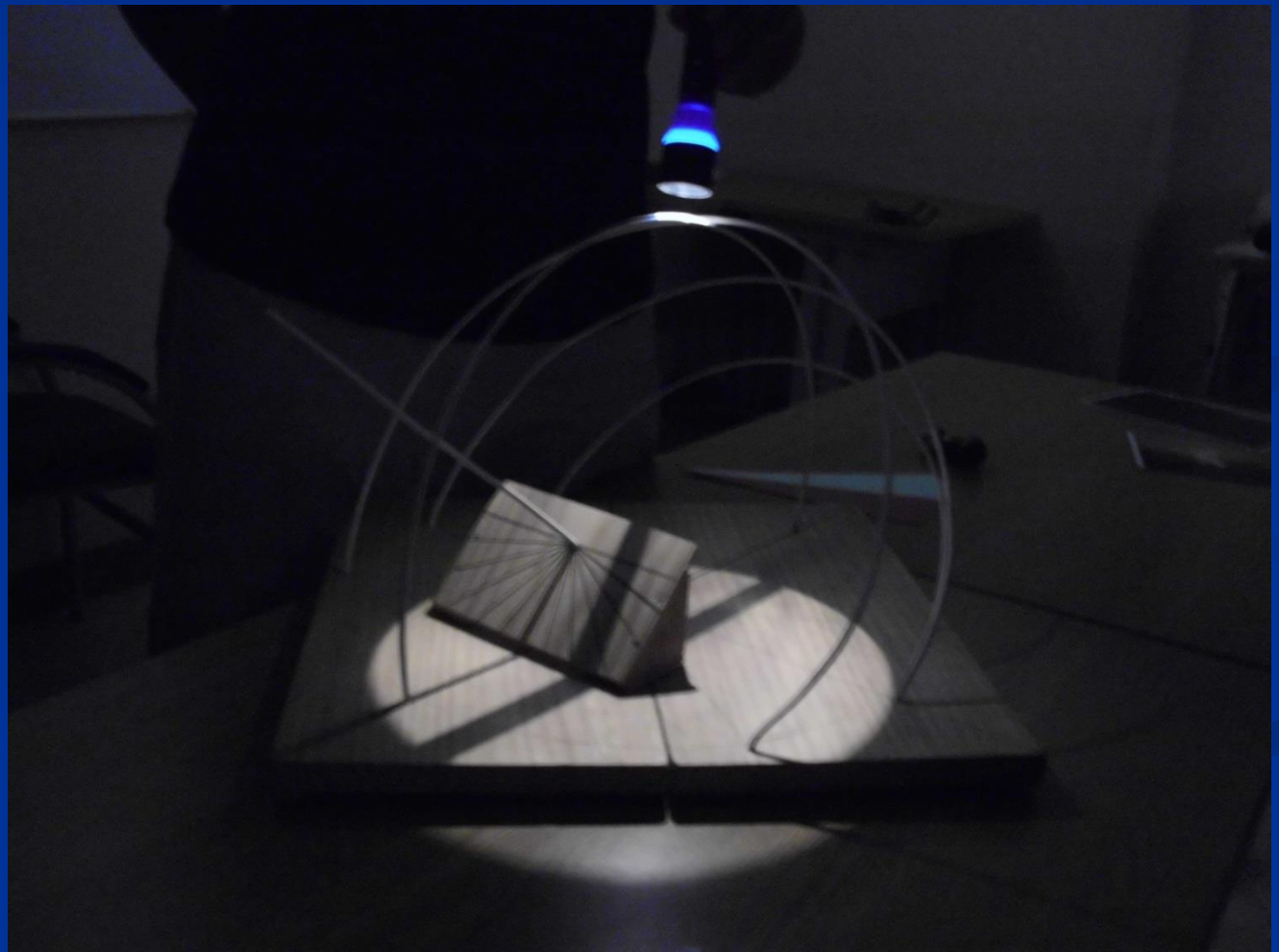
…and the vertically oriented E-W sundial

垂直式日晷



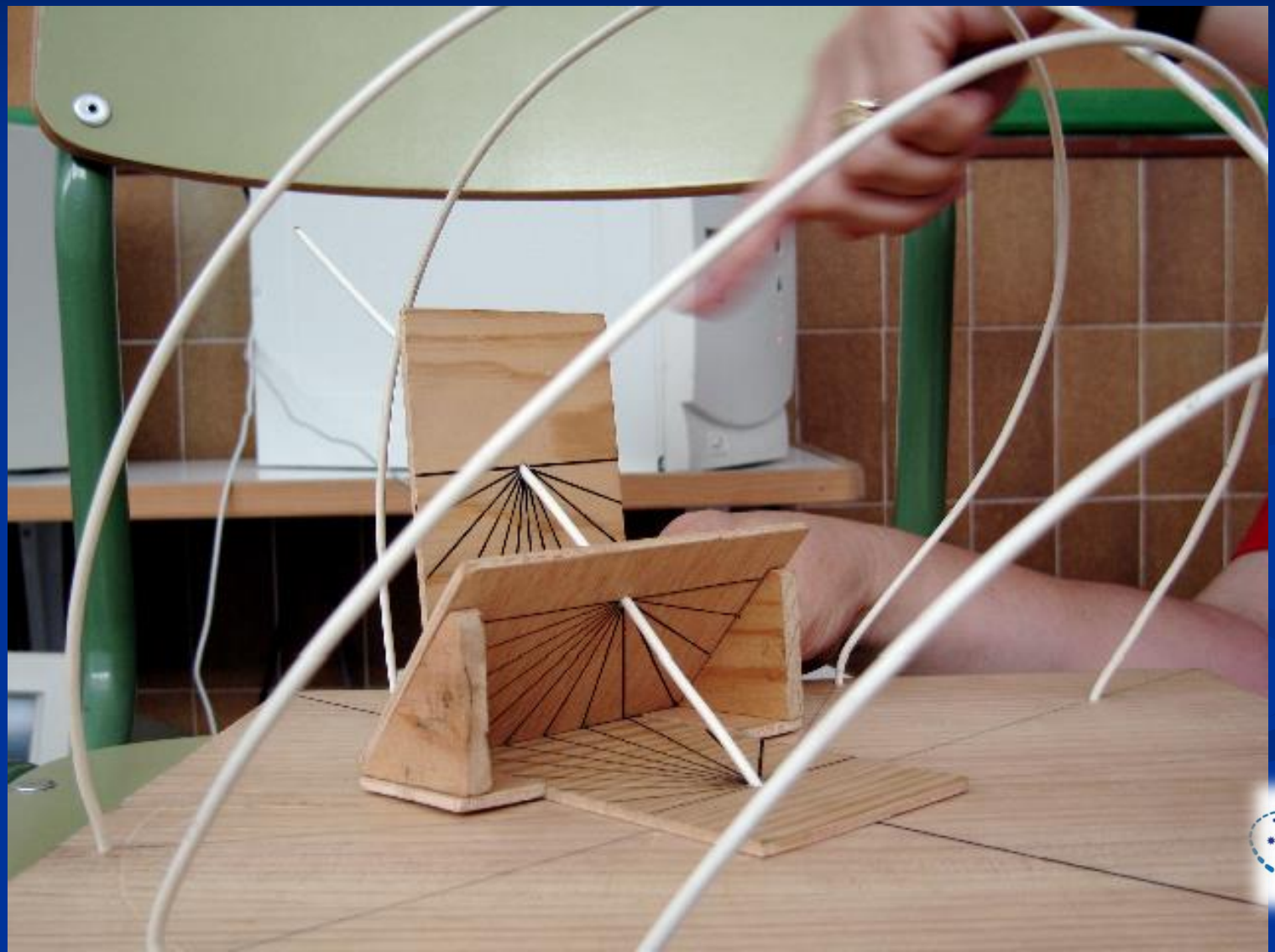
… and with the Sun (or with a flashlight) we observe the model acting like a sundial

…在太阳（或手电）的照射下，我们观察到这个模型像日晷一样



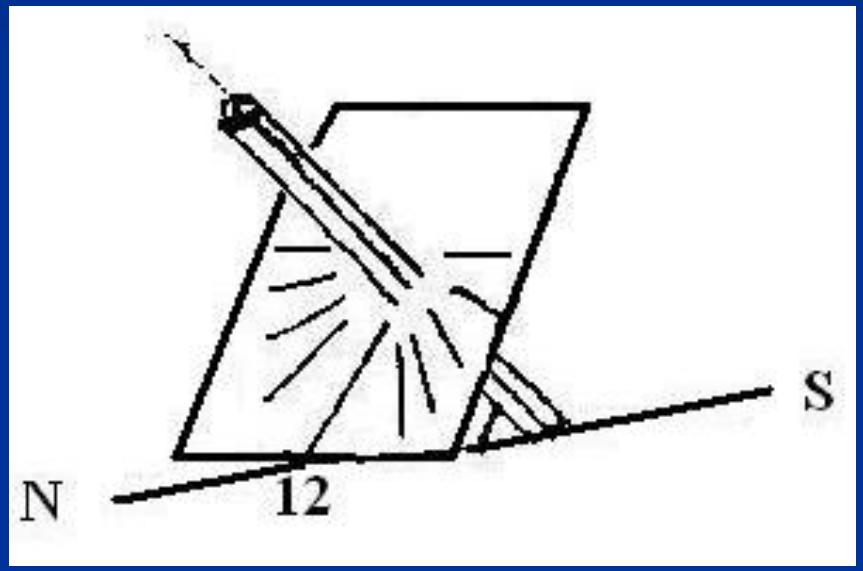
The three sundials in the model

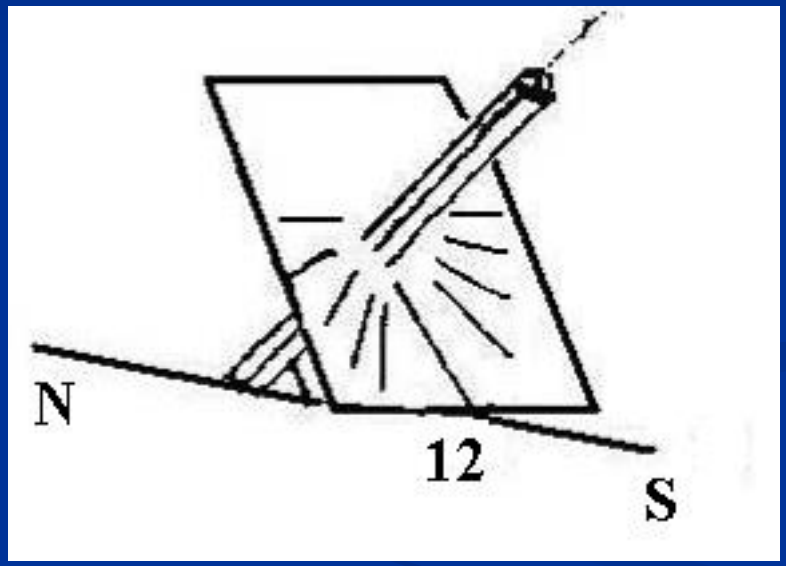
模型中的三个日晷



Activity 4: Let‘s see how to build a very simple “equatorial” sundial!

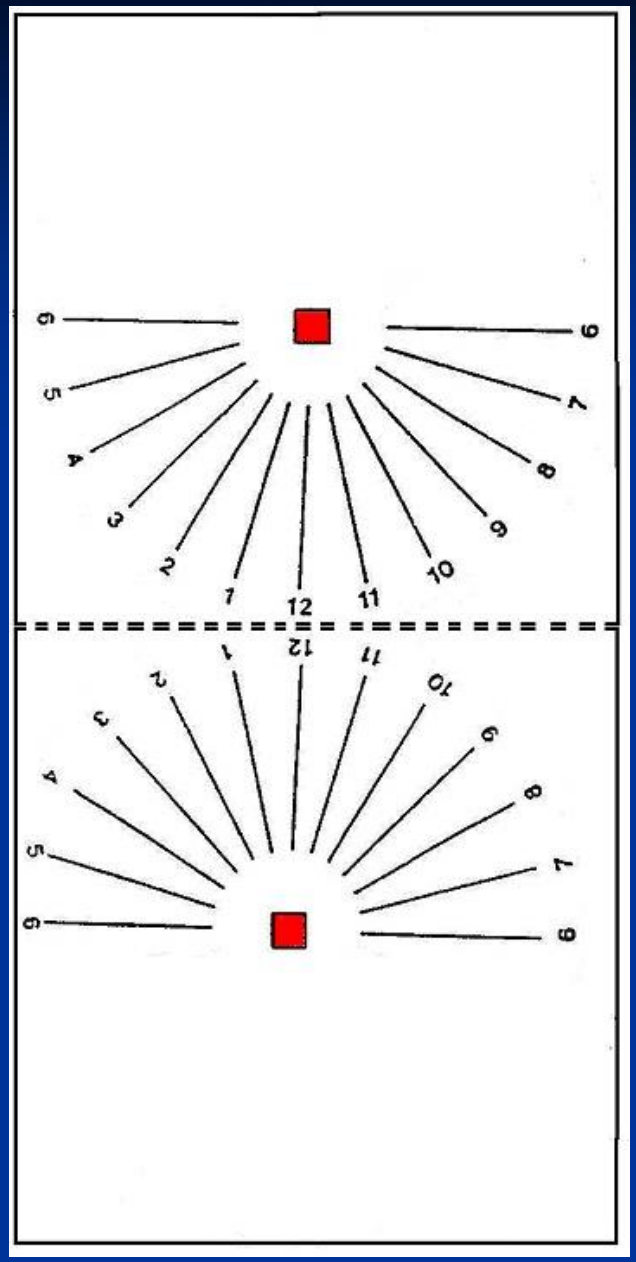
活动4：我们来看看如何制作一个非常简单的“赤道式”日晷！

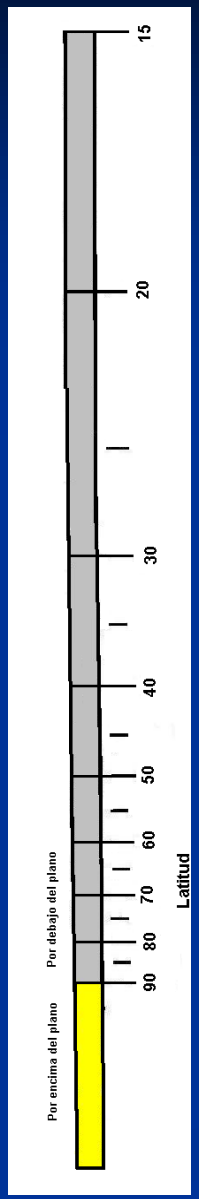




- Northern Hemisphere
- 北半球

- Southern Hemisphere
- 南半球





Activity 4: “equatorial” sundial!

活动4：“赤道式”日晷

- Fold the pattern along the dotted line
- 沿虚线折叠
- Cut the stylus for your latitude. The yellow part goes above the plane
- 按照你的纬度剪下指针，黄色部分位于盘面之上。

Activity 5: How to Read the Time

活动5：怎样读出时间

Solar Time + Total Adjustment = Wristwatch Time

太阳时+ 总调整=手表时间

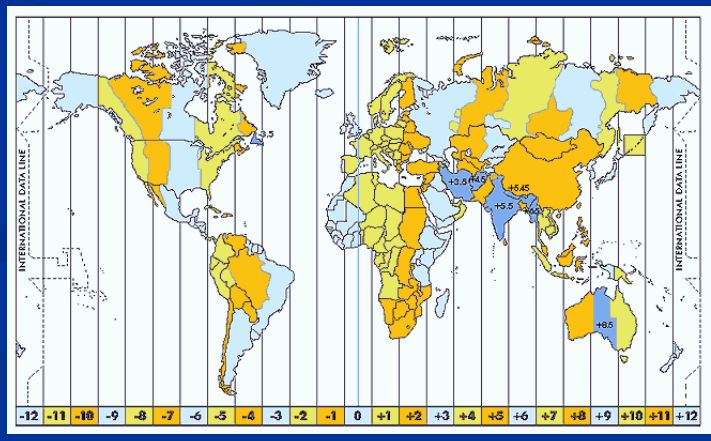
Total Adjustment = 总调整=

- **Longitude Adjustment** 经度调整
- **Summer / Winter Adjustment** 冬夏调整
- **Equation of Time Adjustment** 时间等式调整

Activity 5: Read the time, Longitude Adjustment

活动5：读出时间，经度调整

- The world is divided into 24 time zones from the Zero or Greenwich meridian.
- 全球从本初子午线/格林威治子午线起，被划分为24个时区。
- We must know the local longitude and "Standard" meridian longitude of your area.
- 我们必须知道所在地区的当地经度，以及“标准” 经度。
- Use sign + to the East and sign - to the West.
- 以东为+，以西为−。
- Write longitudes in h, m and s (1º=4m).
- 经度单位采用时、分、秒，（1º= 4分）。



Activity 5: Read the time, Summer / Winter Adjustment

活动5：读出时间，冬夏调整

- Many countries add an hour in summer.

•很多国家在夏天都要加一小时

- This change of clocks for summer / winter is a decision of the government of the country.

•冬夏调整由该国政府决定

Activity 5: Read the time, Equation of Time Adjustment

活动5：读出时间，时间等式调整

- The Earth revolves around the Sun according the law of areas, i.e. not a constant motion. We define the average time (of mechanical watches) as the average over a full year.
- 地球围绕太阳公转遵循各个区域的规律，即：不是匀速的。我们将一年的平均定义为（机械时钟的）平均时间。
- The equation of time is the difference between "Real Solar Time" and "Mean Time" in minutes of time
- 这个时间等式就是“真太阳时”和“平时”的差值。

day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	+3m 33s	+13m 35s	+12m 22s	+3m 54s	-2m 54s	-2m 12s	+3m 50s	+6m 21s	+0m 2s	-10m 18s	-16m 24s	-11m 1s
6	+5m 50s	+14 m 5s	+11m 17s	+2m 27s	-3m 23s	-1m 22s	+4m 45s	+5m 54s	-1m 23s	-11m 51s	-16m 22s	-9m 1s
11	+7m 55s	+14m 14s	+10m 3s	+1m 4s	-3m 38s	-0m 23s	+5m 29s	+5m 13s	-3m 21s	-13m 14s	-15m 31s	-6m 49s
16	+9m 45s	+14m 4s	+8m 40s	-0m 11s	-3m 40s	+0m 39s	+6m 3s	+4m 17s	-5m 7s	-14m 56s	-15m 15s	-4m 27s
21	+11m 18s	+13m 37s	+7m 12s	-1m 17s	-3m 27s	+1m 44s	+6m 24s	+3m 10s	-6m 54s	-15m 21s	-14m 10s	-1m 58s
26	+12m 32s	+12m 54s	+5m 42s	-2m 12s	-3m	+2m 49s	+6m 32s	+1m 50s	-8m 38s	-16m 1s	-12m 44s	+0m 31s
31	+13m 26s		+4m 12s		-2m 21s		+6m 24s	+0m 21s		-16m 22s		+1m 5

Activity 5: Reading Time

Example 1: Barcelona (Spain) on May 24th

Adjustment	Comment	Result
1. Longitude	Barcelona is in the same "standard" zone as Greenwich. Its longitude is 2º 10' E = 2.17º E = -8.7 m (1° is equivalent to 4 m)	-8.7 m? +8.7m
2. Summer Time	May has daylight saving of +1 h	+ 60 m
3. Equation of Time	We read the table for May 24th	-3.4 m
Total		+47.7 m

For example at 12h of solar time (noon), our watches indicated (Solar time) 12h + 47.9 m = 12h 47.9 m (wristwatch time)

活动5：读出时间

例1：5月24日巴塞罗那（西班牙）

调整	注解	结果
1. 经度	巴塞罗那与格林威治在同一标准经度。其经度为2°10'E=2.17°E= - 8.7m（1° = 4 m）	-8.7 m？ +8.7m
2. 夏令时	5月采用夏令时，+1 h	+ 60 m
3. 时间等式	从表中读取5月24日	-3.6 m
合计		+47.7 m

例如，太阳时是12:00（正午），手表的时间是
（太阳时）12h + 47.7 m = 12h 47.7 m （手表时间）

Activity 5: Reading Time

Example 2: Tulsa, Oklahoma (USA) November 16th

Adjustment	Comment	Result
1. Longitude	The standard meridian of Tulsa is 90 ° W. Its longitude is 95º 58' W = 96 º W, so it is 6° W from the standard meridian (1° is equivalent to 4 m)	+24 m
2. Winter Time	November 16th does not have daylight saving added	0
3. Equation of Time	We read the table for November 16th	-15.3 m
Total		+ 8.7 m

For example at 12h solar time (noon), our watches will indicate (Solar time) 12h + 8.7 m = 12h 8.7 m (Wristwatch time)

活动5：读出时间

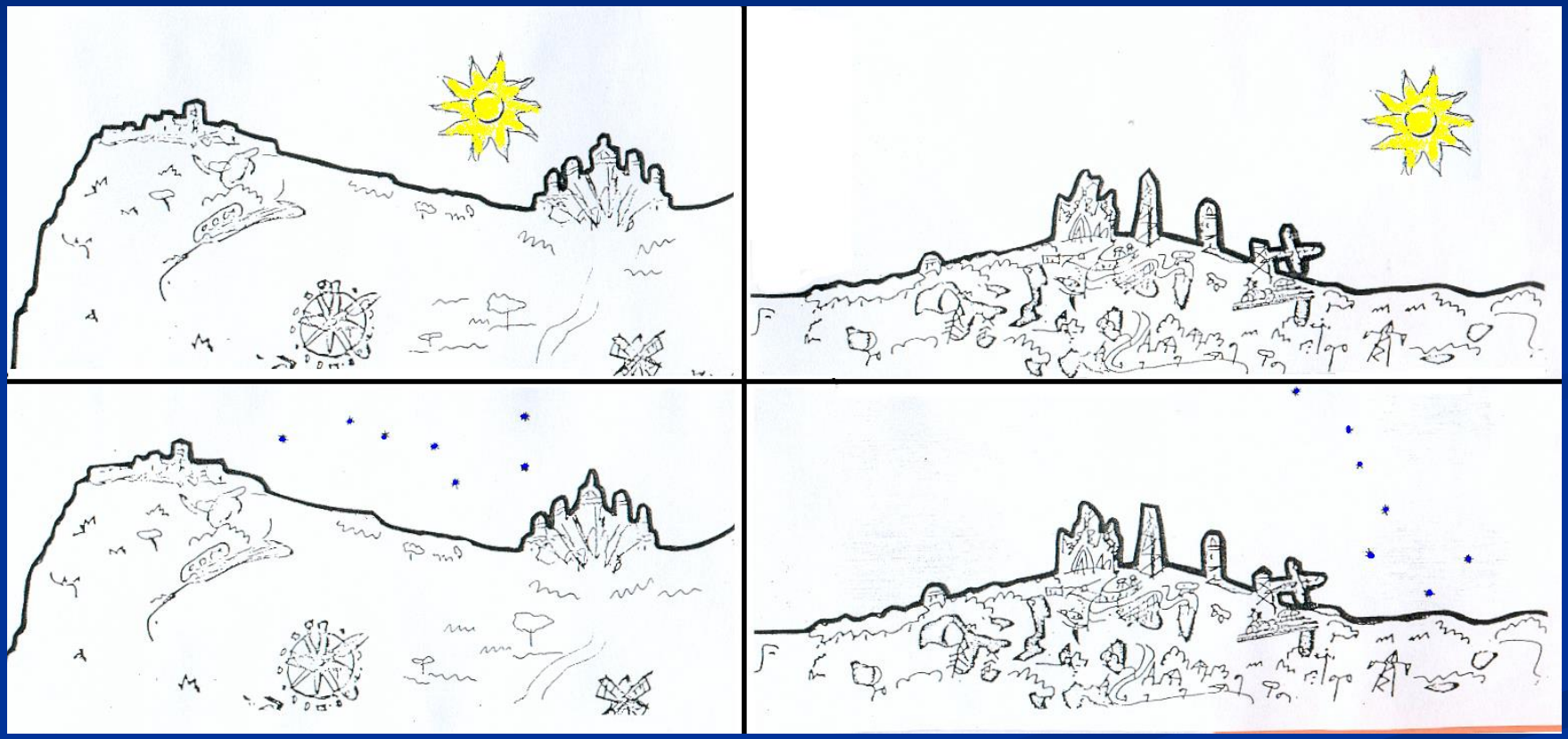
例2： 11月16日塔尔萨，俄克拉荷马州（美国）

调整	注解	结果
1. 经度	标准经度为90°W，实际经度为95°58’W，大约96°W，即距离格林威治标准经度6°W。（1° = 4 m）	+24 m
2. 夏令时	11月16日不是夏令时。	0
3. 时间等式	从表中读取11月16日。	-15.3 m
合计		+ 8.7 m

例如，太阳时是12:00（正午），手表的时间是
（太阳时） 12h + 8.7 m = 12h 8.7 m（手表时间）

the model serves to orientate us …

模型帮助我们定位方向…



… to observe and understand …

…观察和理解

Conclusions
总结

- We understand the "views" of the model from inside and outside
  - 我们理解了从模型的内部和外部看到的景象
- We reach levels of abstraction that let us read books and make comments
  - 我们达到了可以看书和写评论的抽象水平
- We feel oriented to the real horizon
  - 我们感受到了真实的地平
- We see that the sunrise is not always due East and that the Sunset is not always due West
  - 我们观察到日出不总是在正东，日落也不总是在正西

Thank you very much for your attention!

非常感谢！