

DISTANCES ACROSS THE UNIVERSE

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Why Do We Need Distances?

Planets – Atmosphere, Life

行星 – 大气，生命

Stars – Temperature, Size, Age

恒星 – 温度，大小，年龄

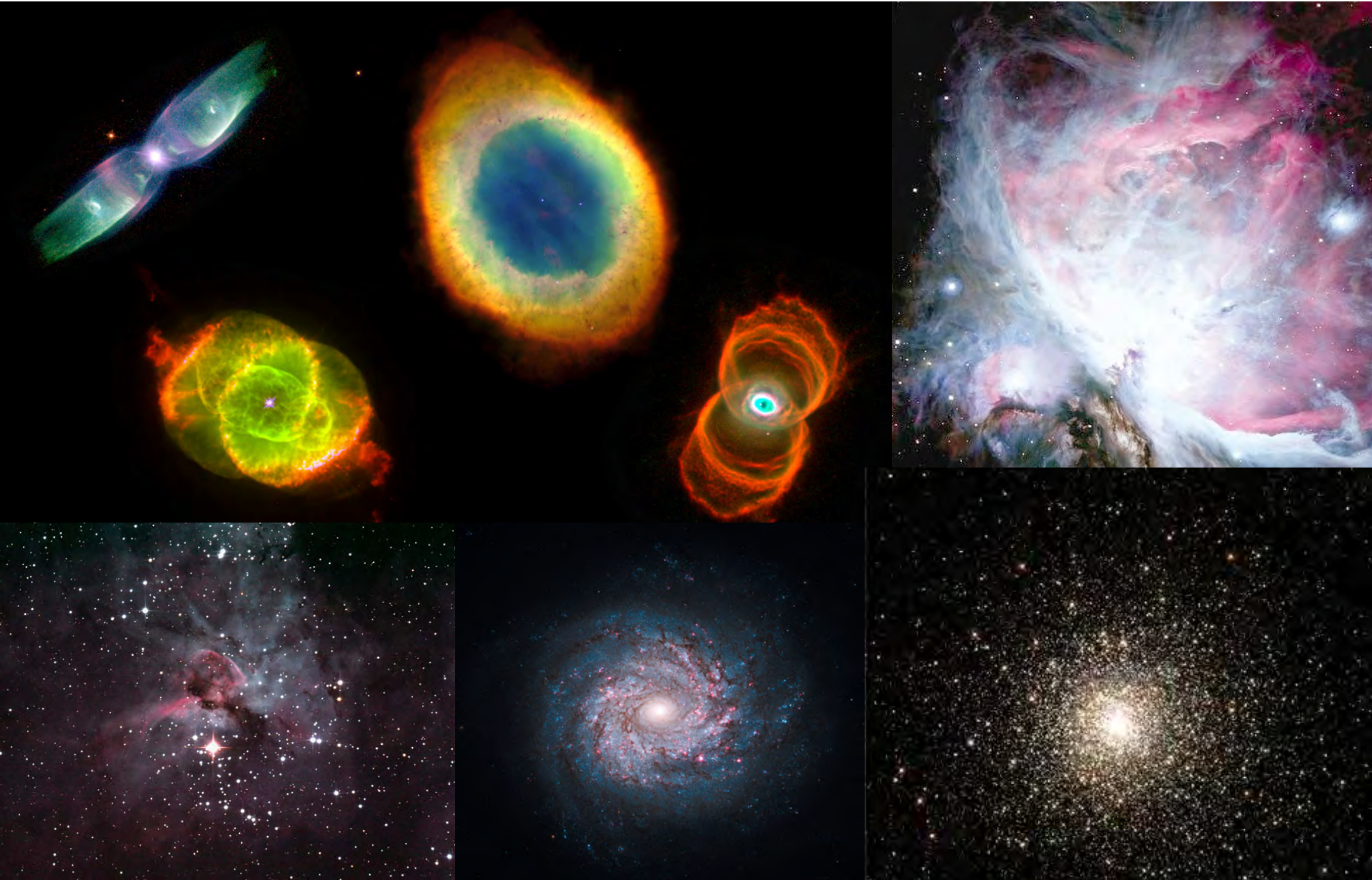
Galaxies – Mass, Dark Matter, Age

星系 – 质量，暗物质，年龄

The Universe – Matter & Energy, Size, Age, Birth and Death

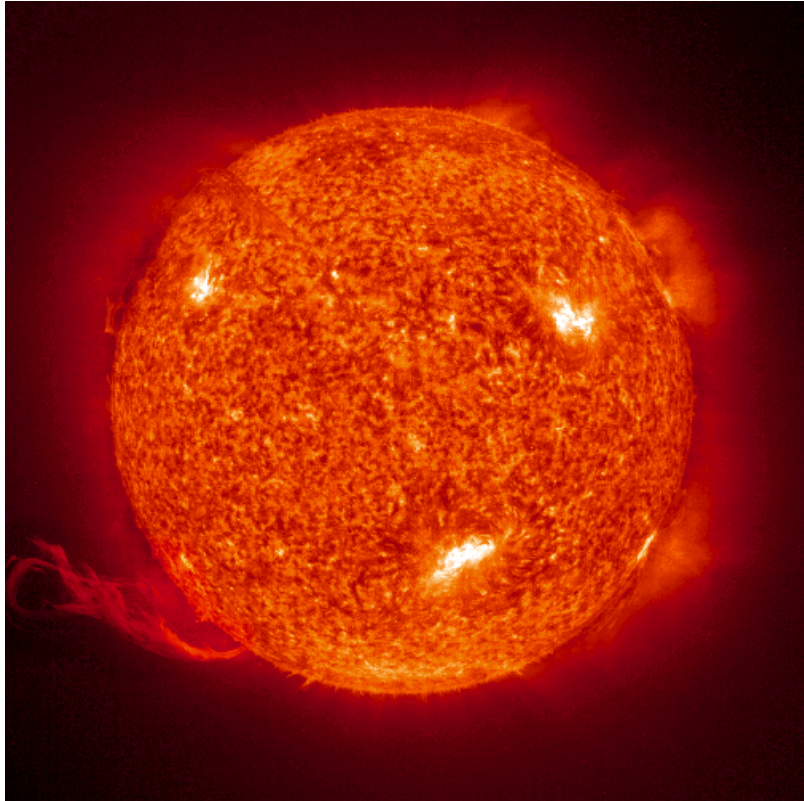
宇宙 – 物质和能量，大小，年龄，起源和终结

Hubble's Great Question – The Nebula Zoo

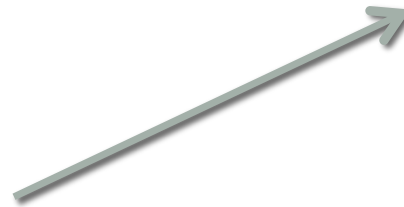


Let's Shrink Our Solar System

如果太阳只有一个篮球那么大

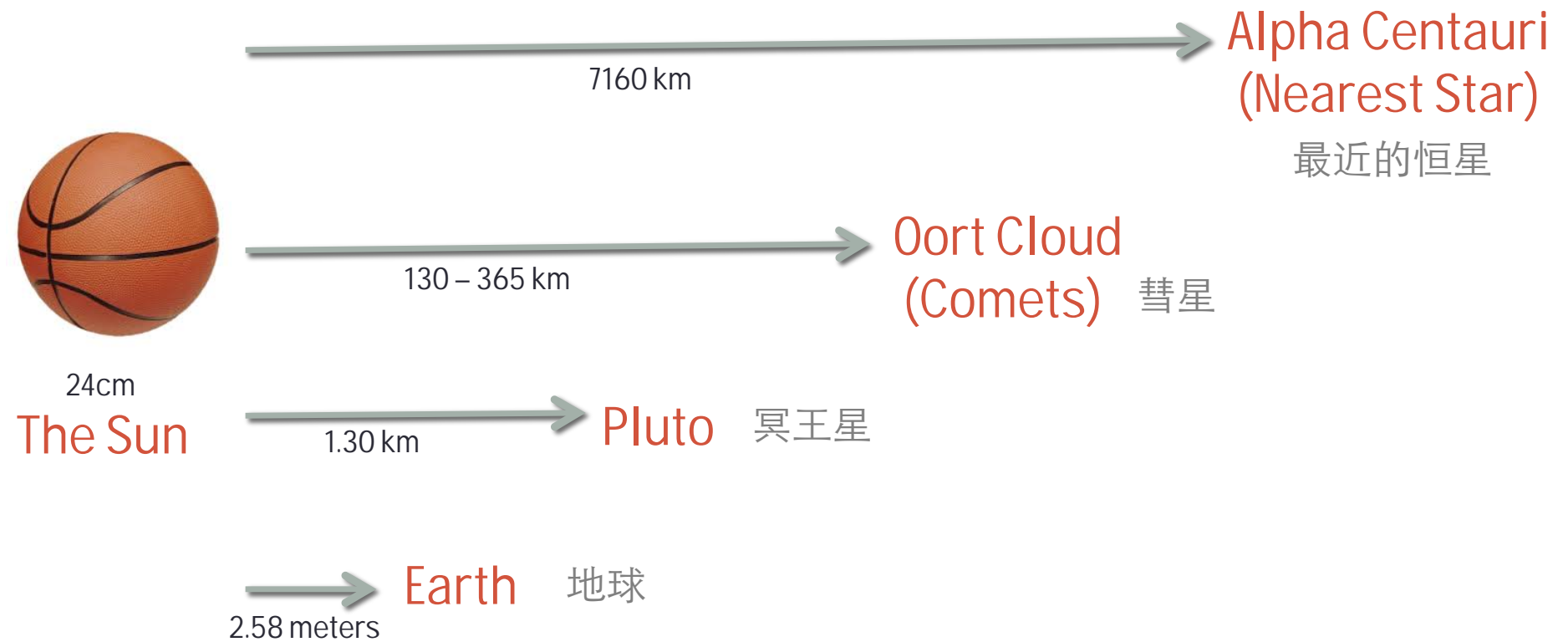


The Sun

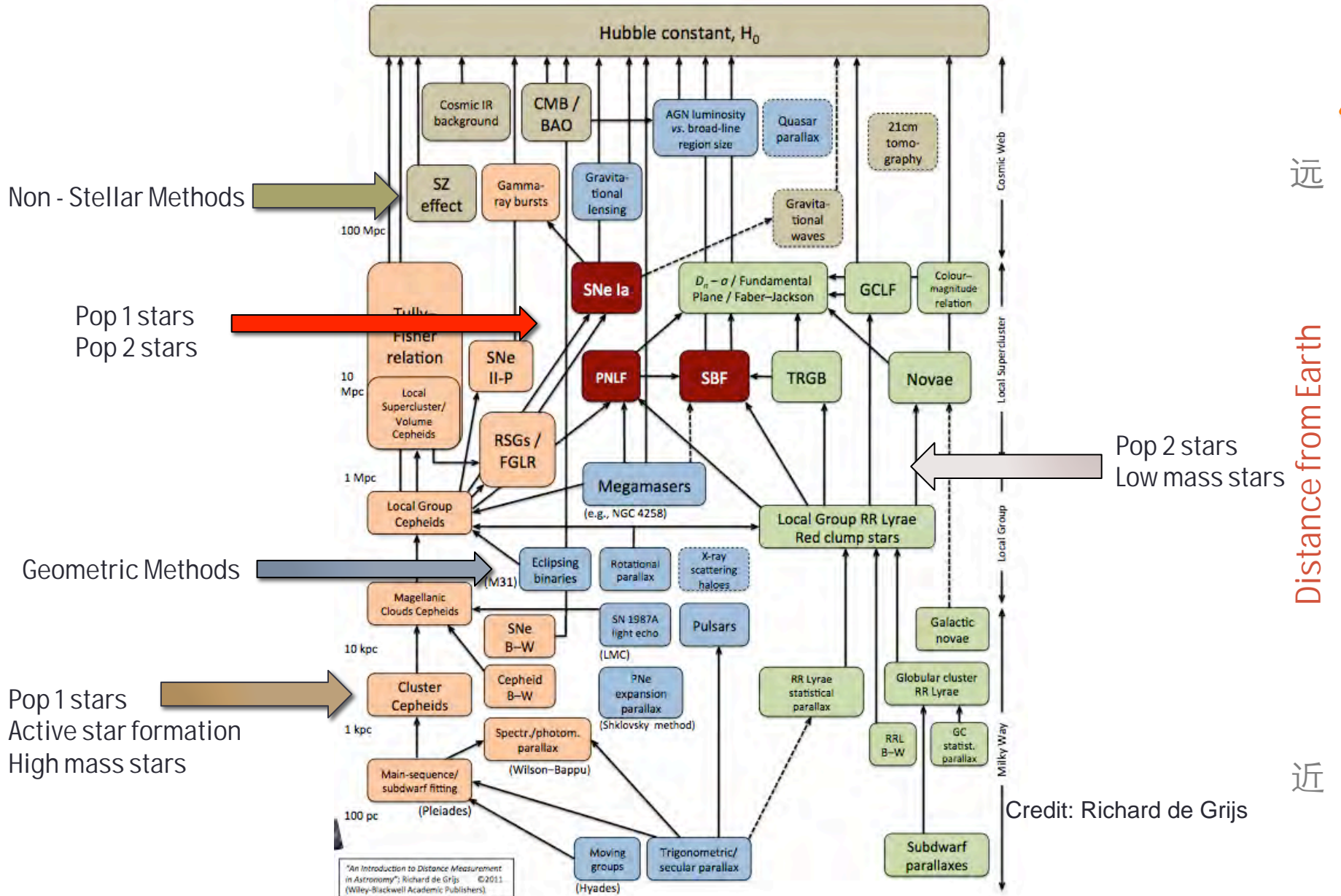


Basketball

Space is Big!



Choose Your Distance Measurement!



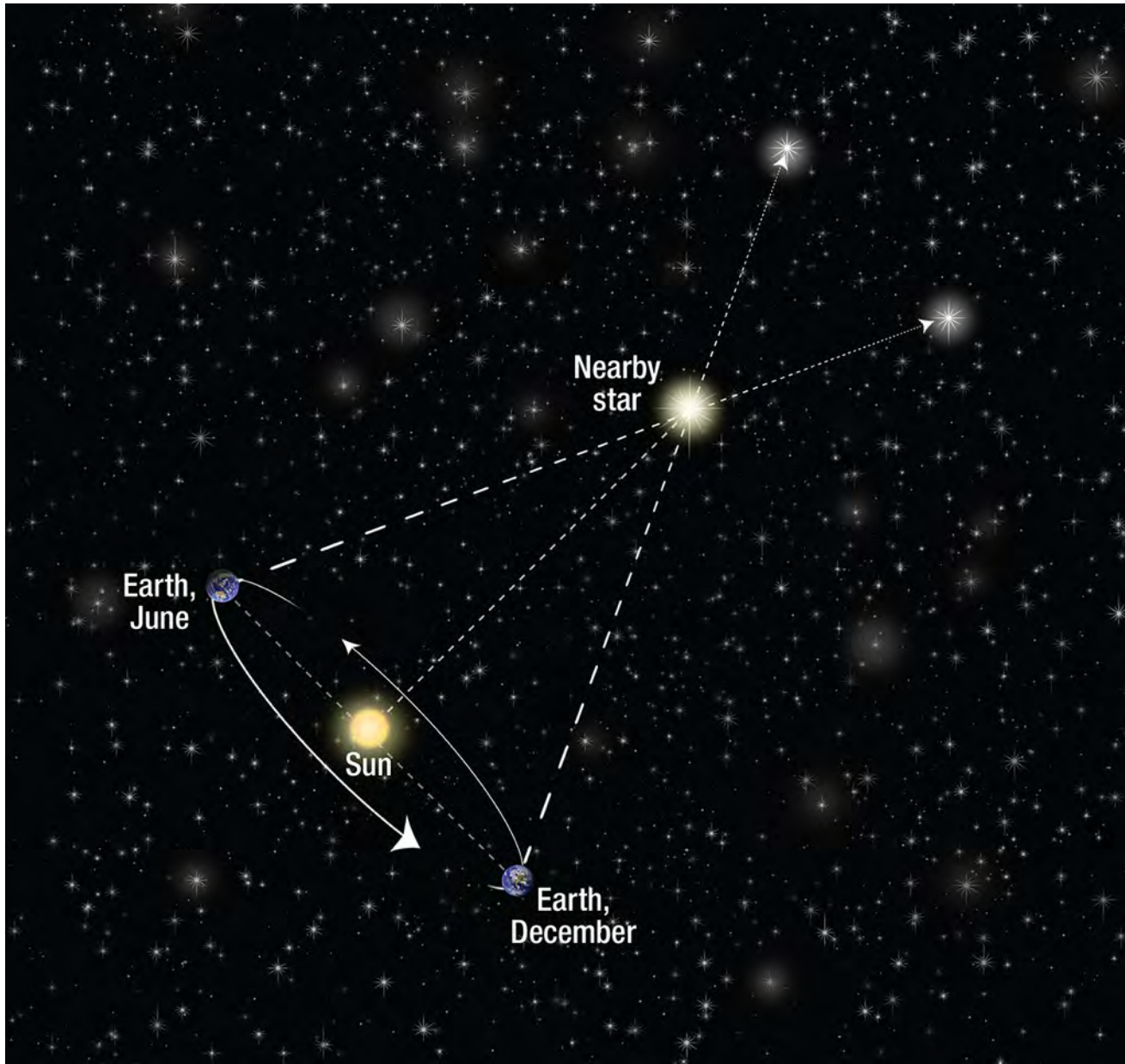
The Cosmic Distance Ladder

宇宙距离阶梯

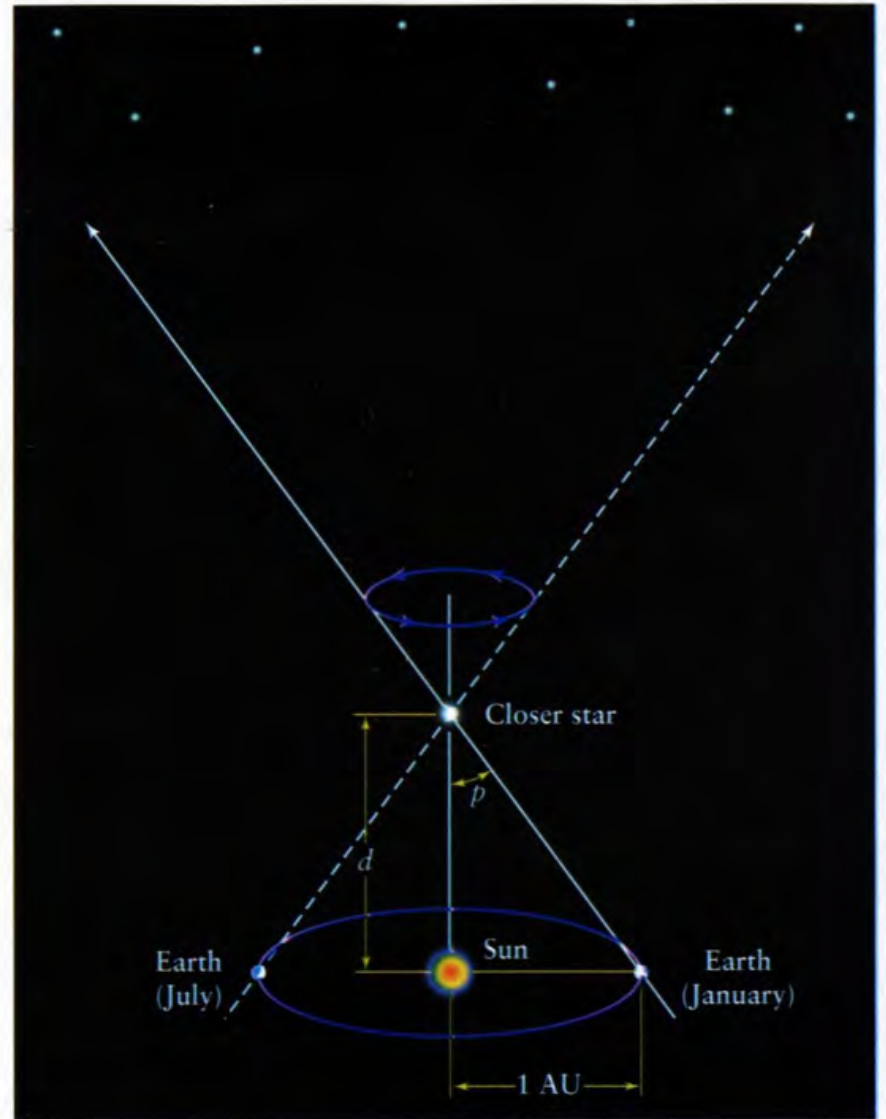
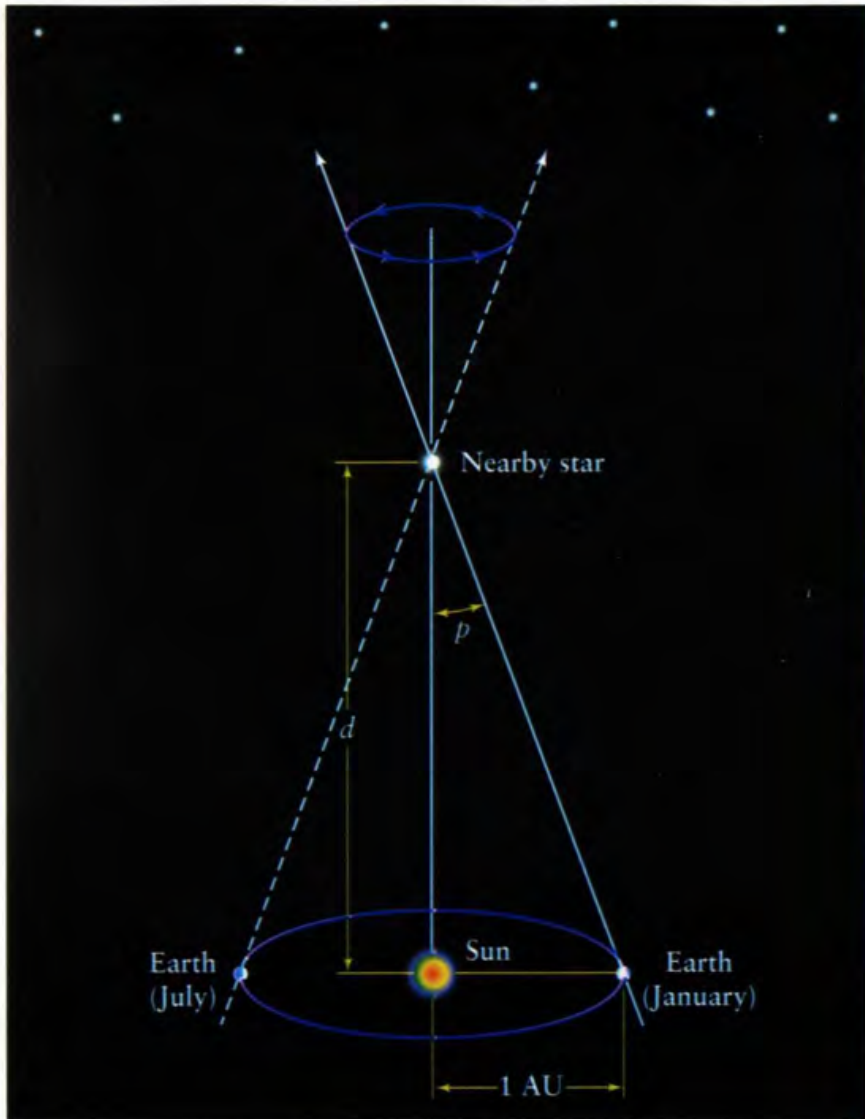


Parallax

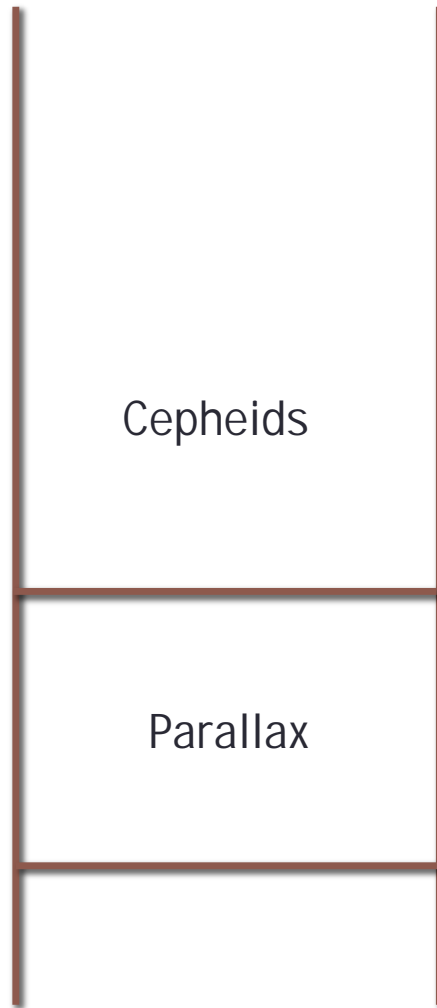
视差法



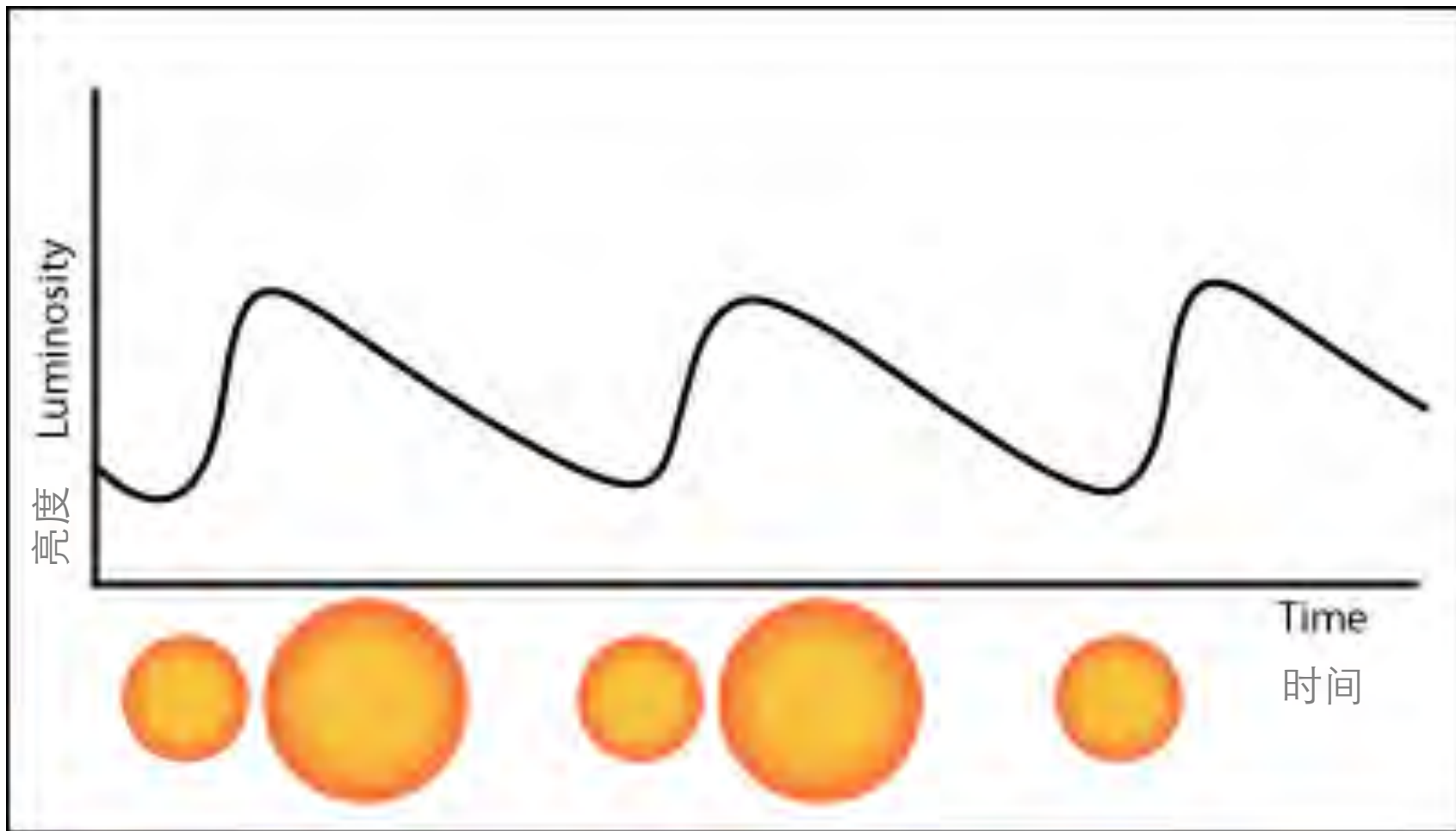
Parallax 视差法



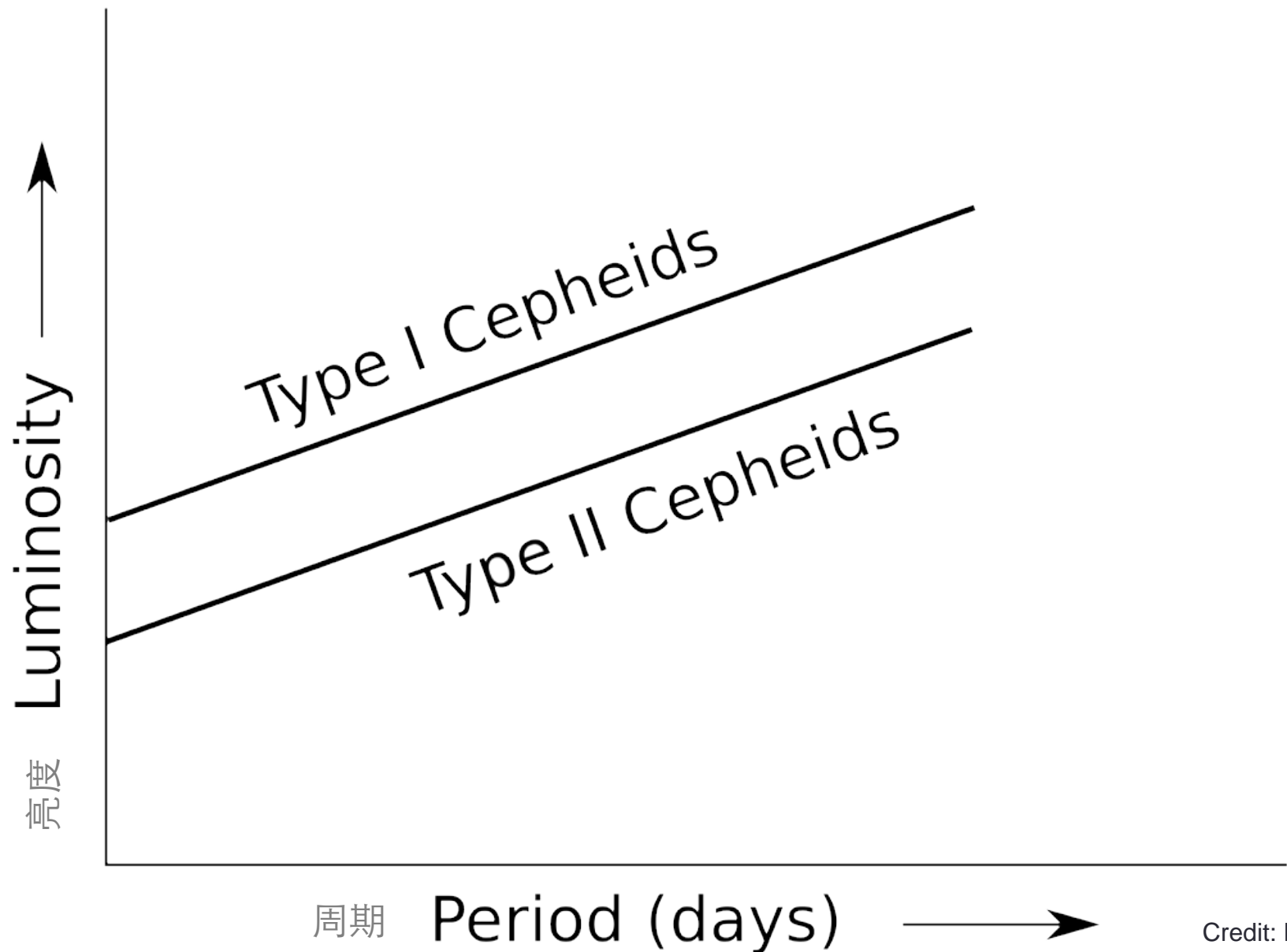
Further Up the Ladder



Cepheid Stars 造父变星



Distances from Cepheid Stars



Hubble Diagram

哈勃图

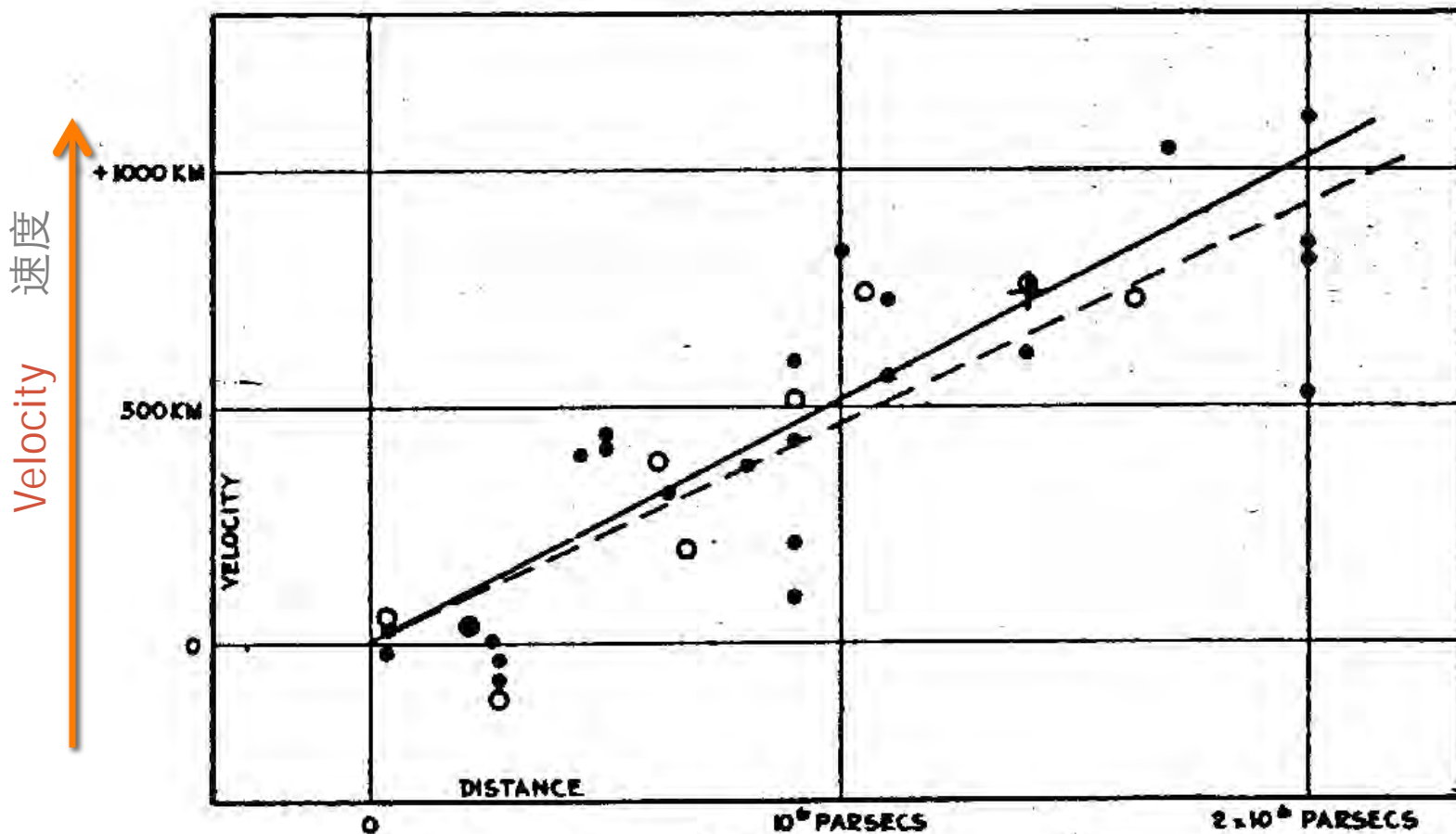
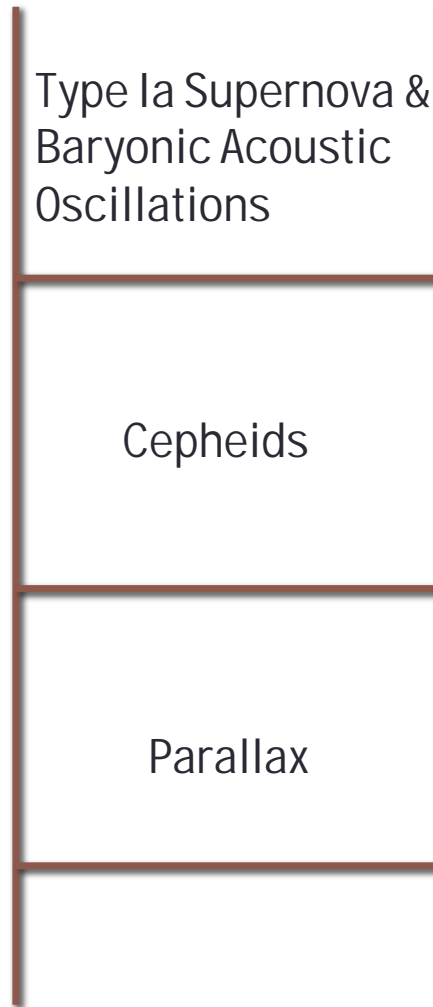


FIGURE 1

Hubble 1936

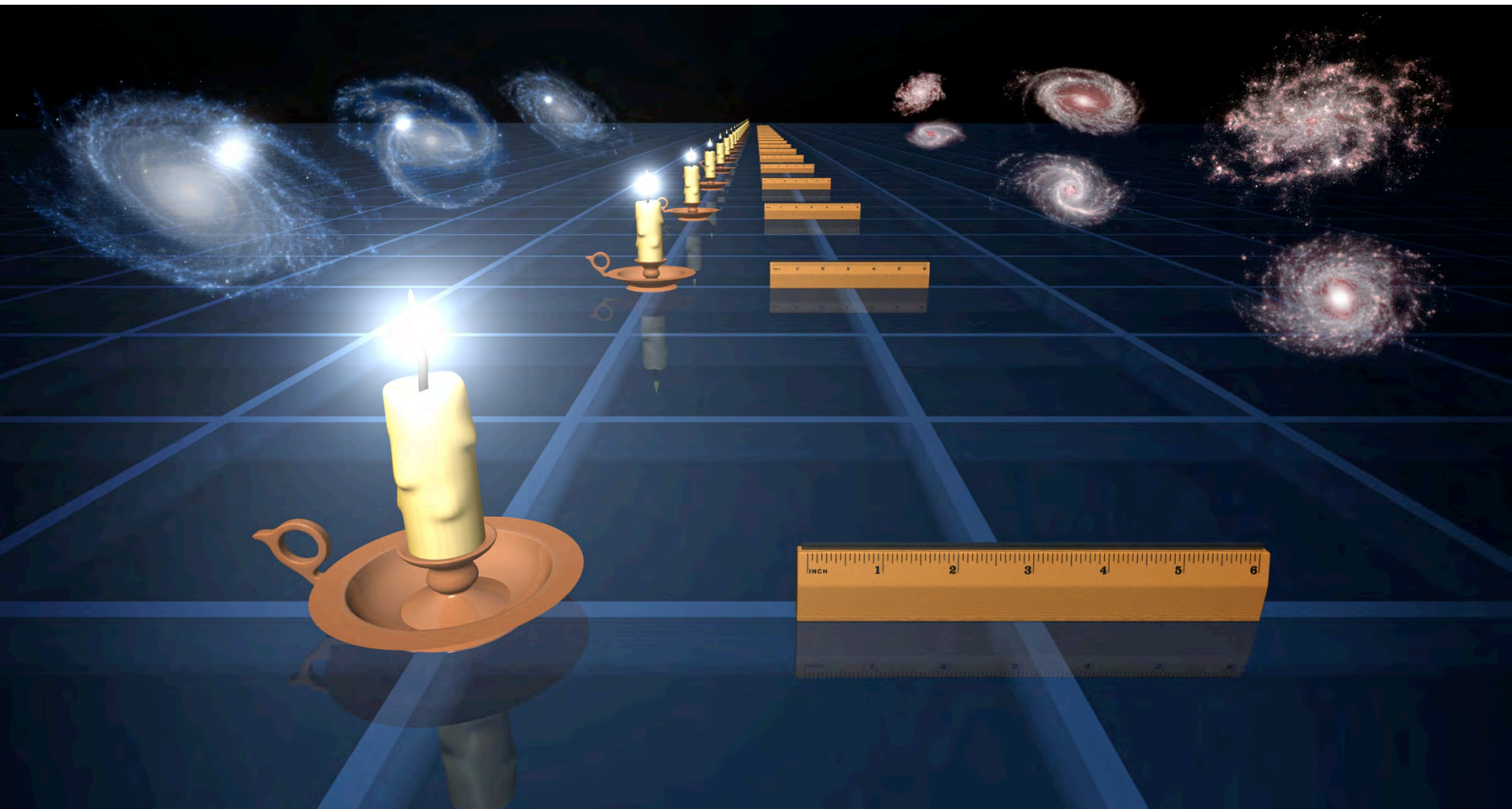
Distance 距离

Still Climbing Up the Ladder



Standard Candles and Rulers

标准烛光，标准尺



Supernova 超新星



Supernova

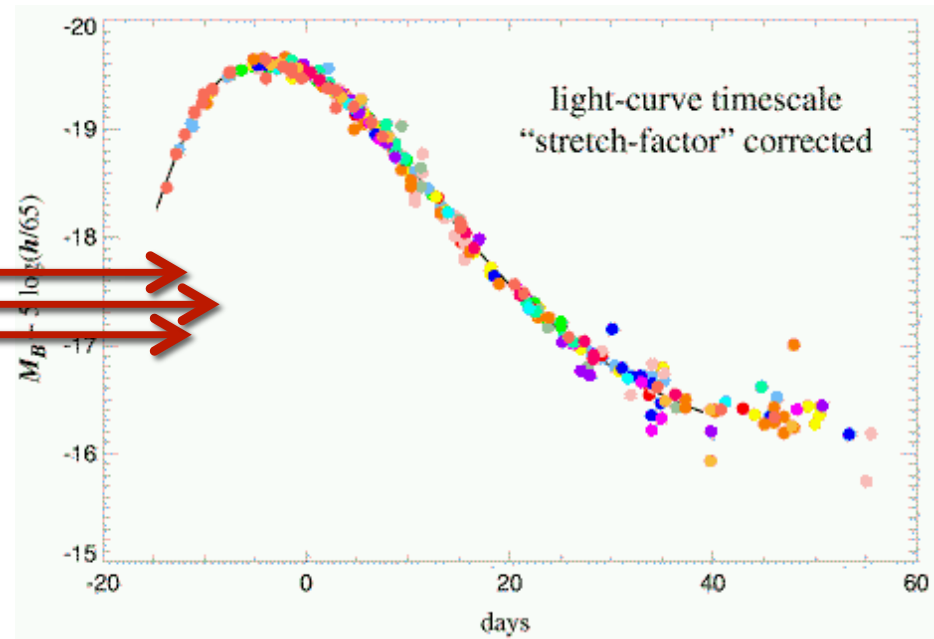
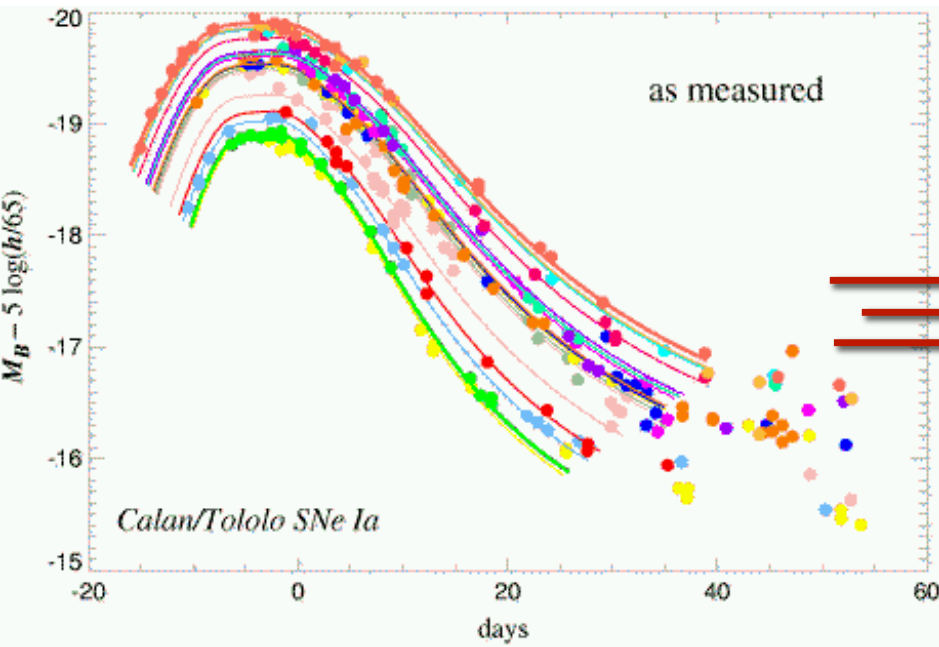
超新星

Start: 26 October 2012
End: 16 January 2013

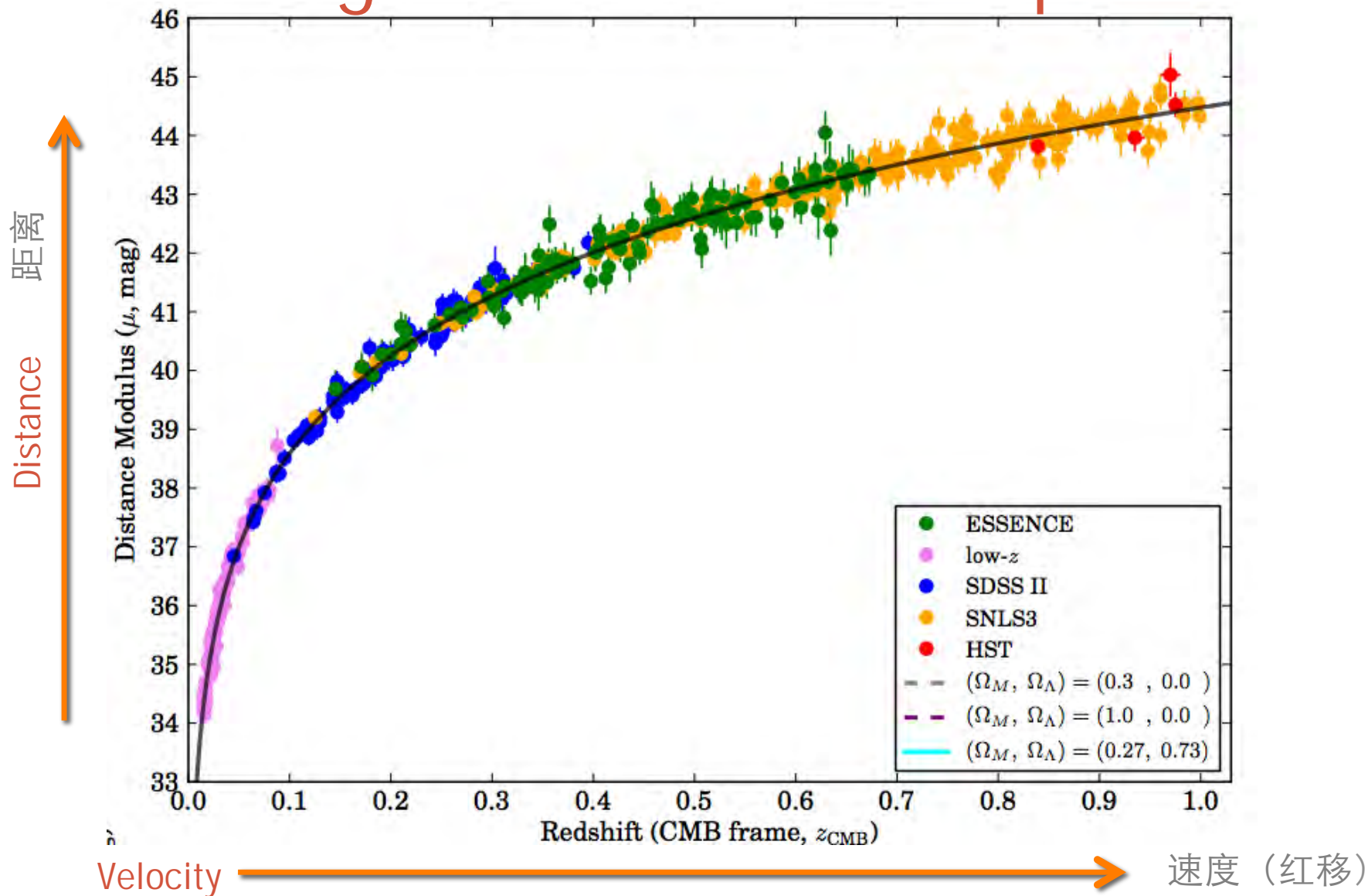


Type Ia Supernova

Ia型超新星的光变曲线



Measuring the Universe with Supernova



Hubble Diagram

哈勃图

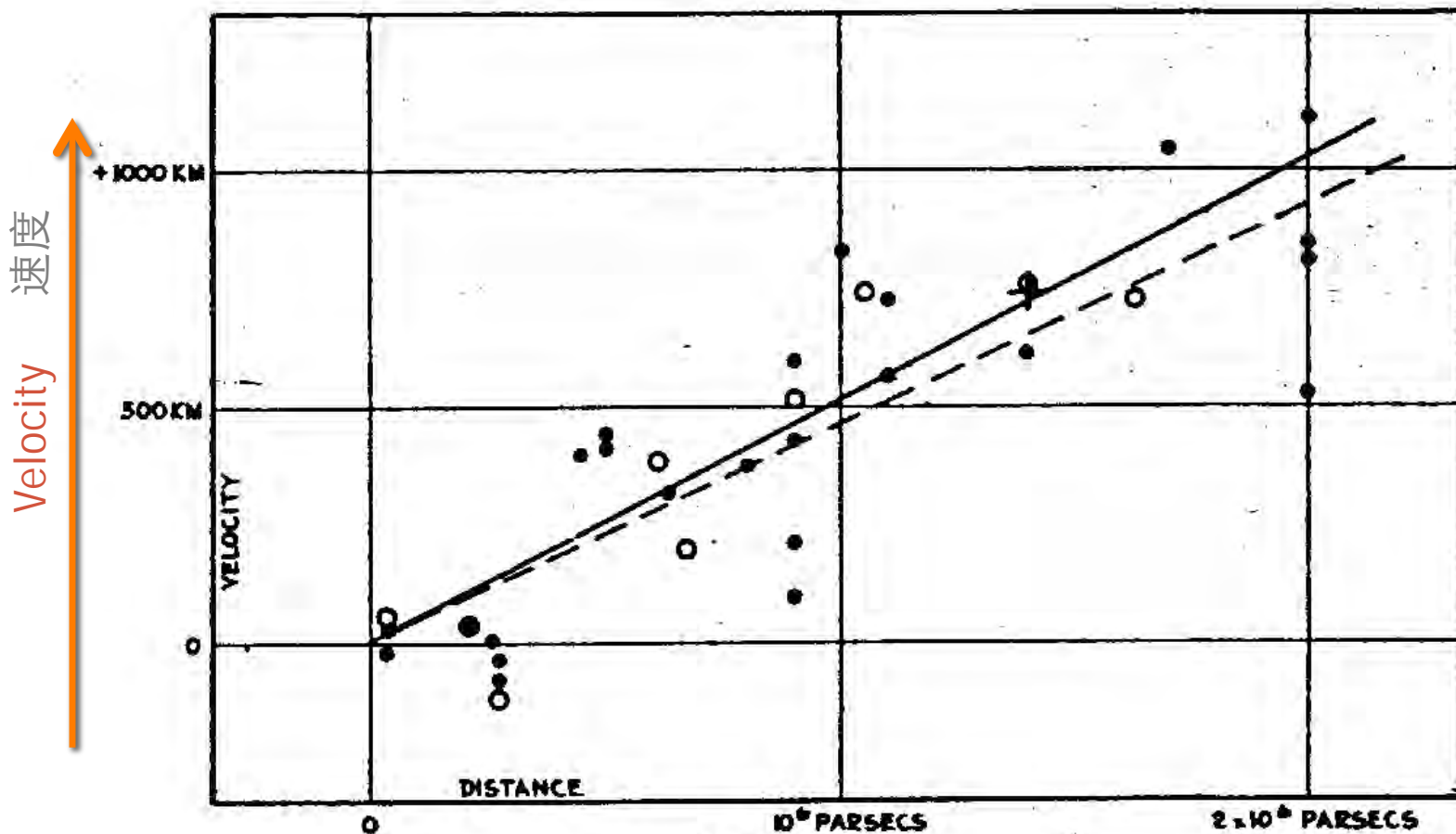
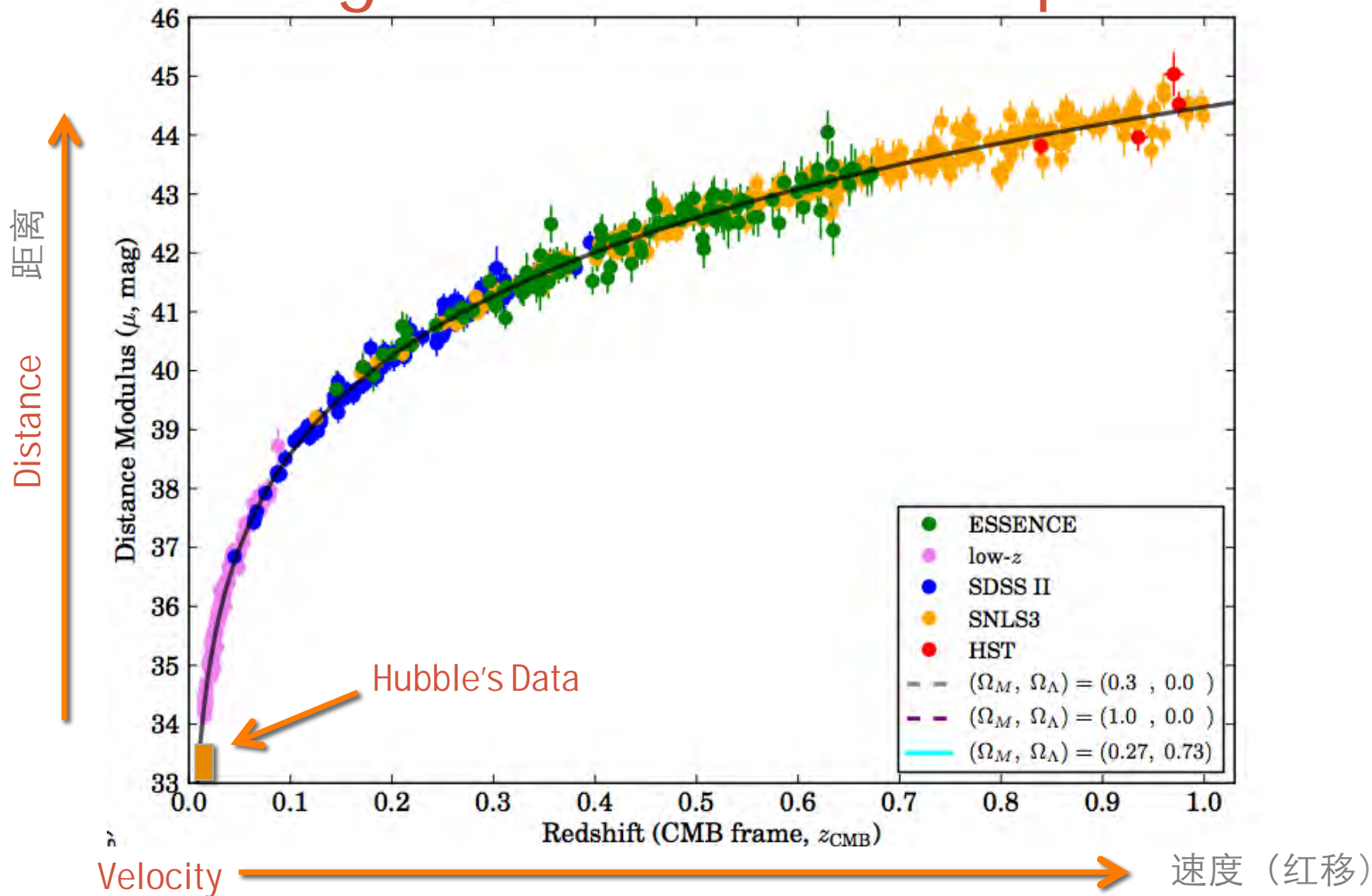


FIGURE 1

Hubble 1936

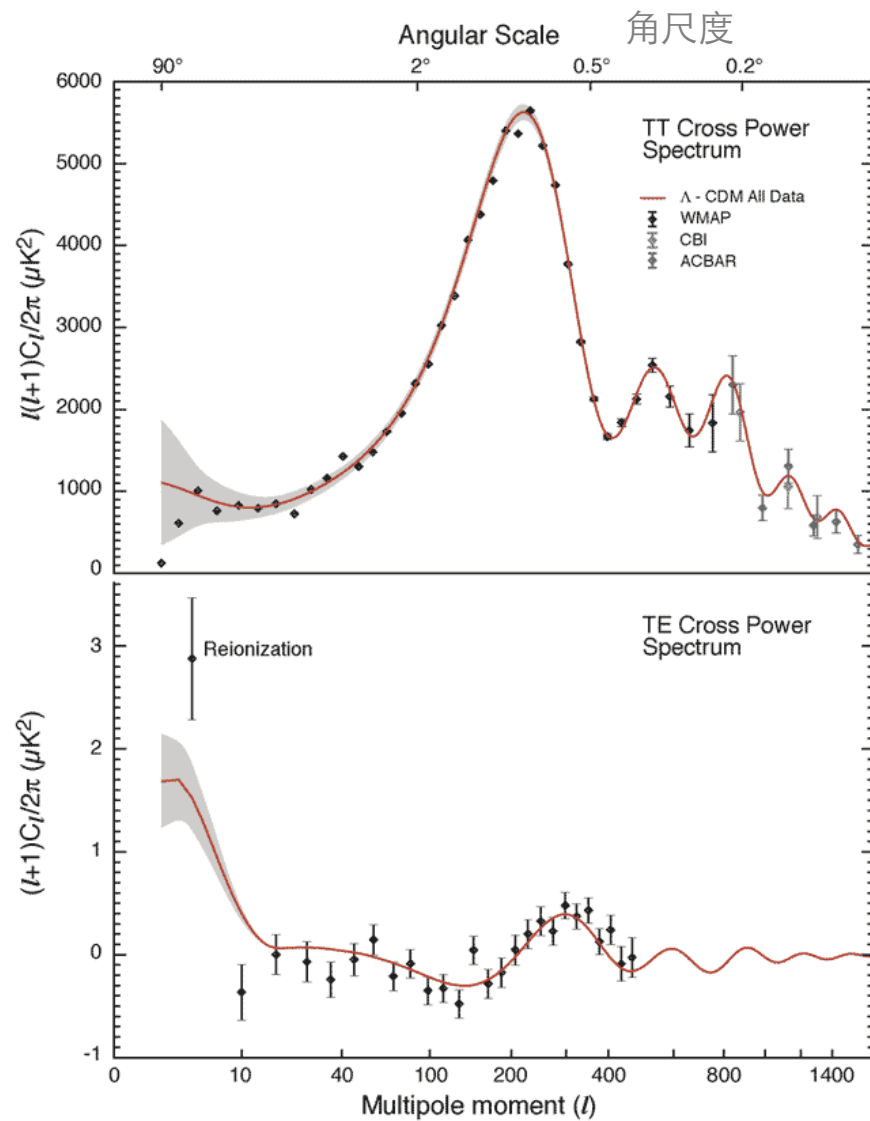
Distance 距离

Measuring the Universe with Supernova



Baryonic Acoustic Oscillations

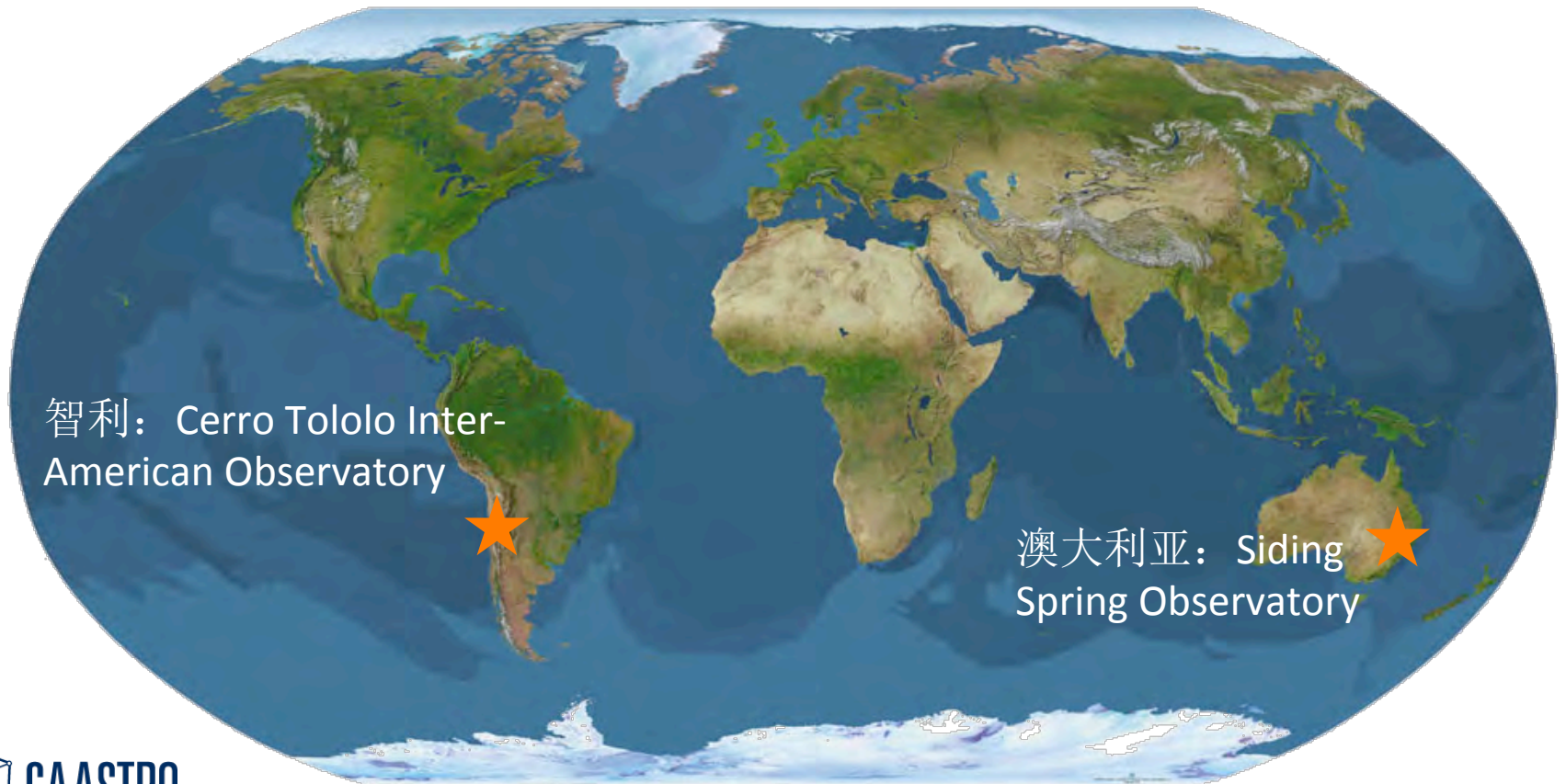
重子声学振荡



寻找暗能量

袁方 博士

(澳洲全天空天体物理中心，澳洲国立大学)



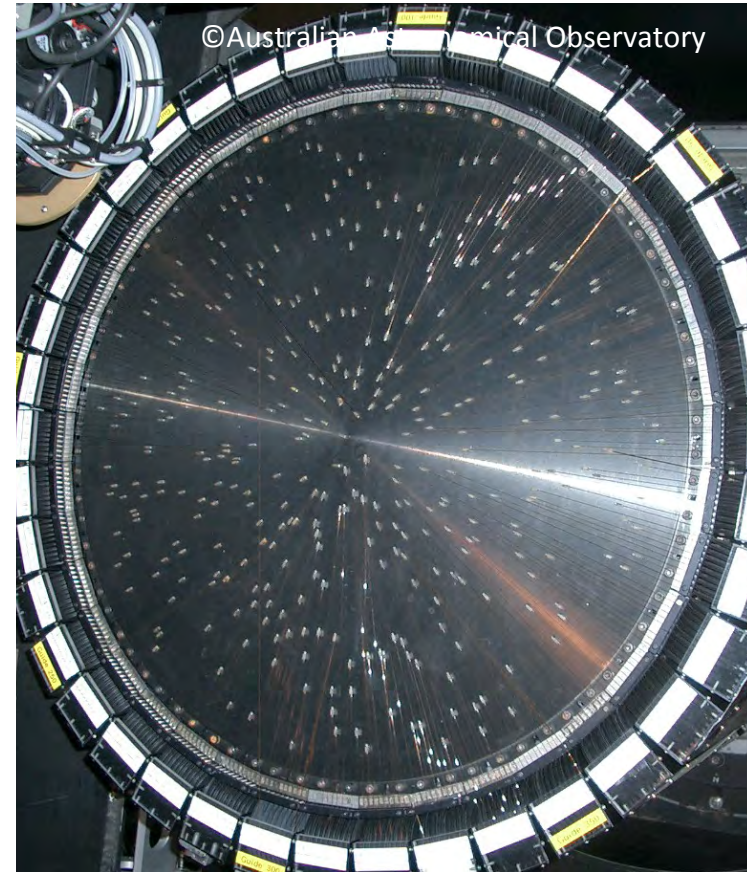
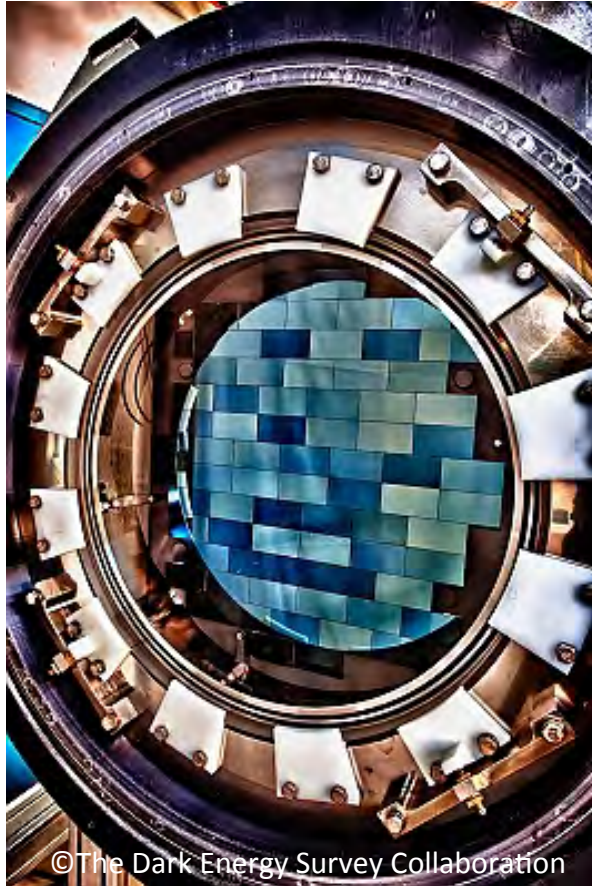
智利: Cerro Tololo Inter-American Observatory

澳大利亚: Siding Spring Observatory

寻找暗能量

Dark Energy Survey (DES) & OzDES





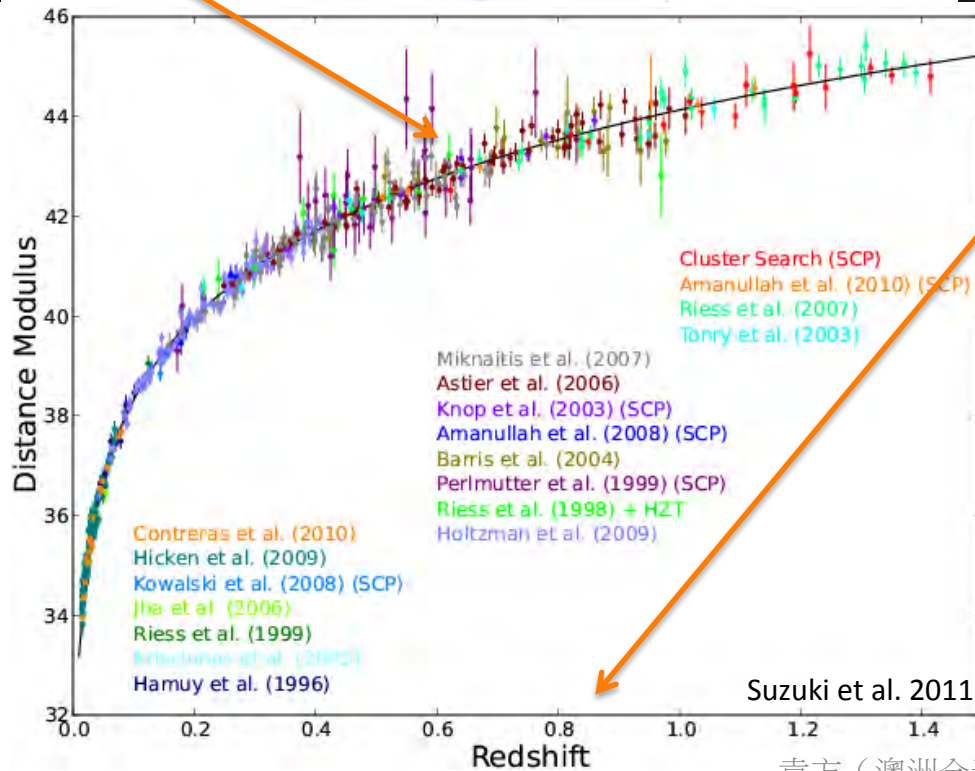
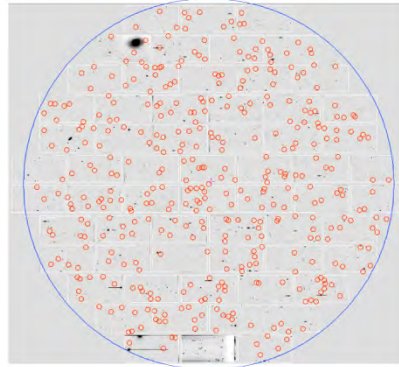
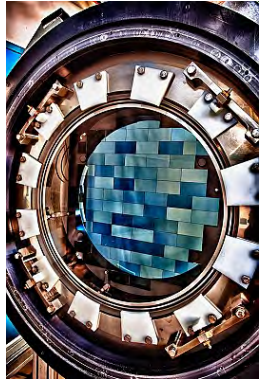
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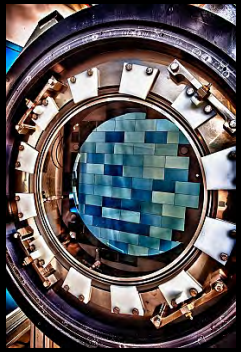


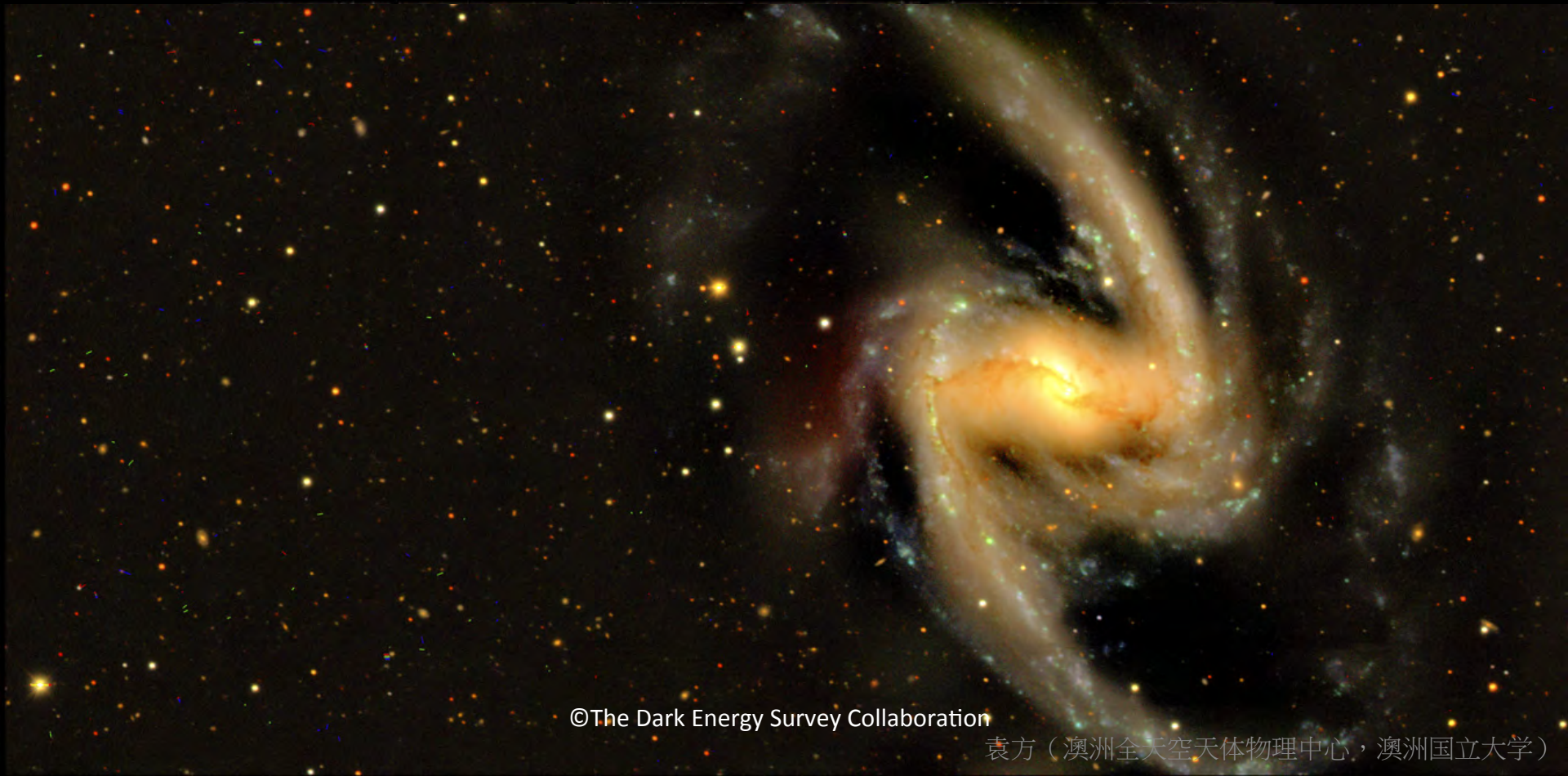
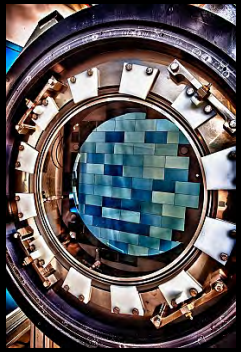
THE DARK ENERGY SURVEY



zDES

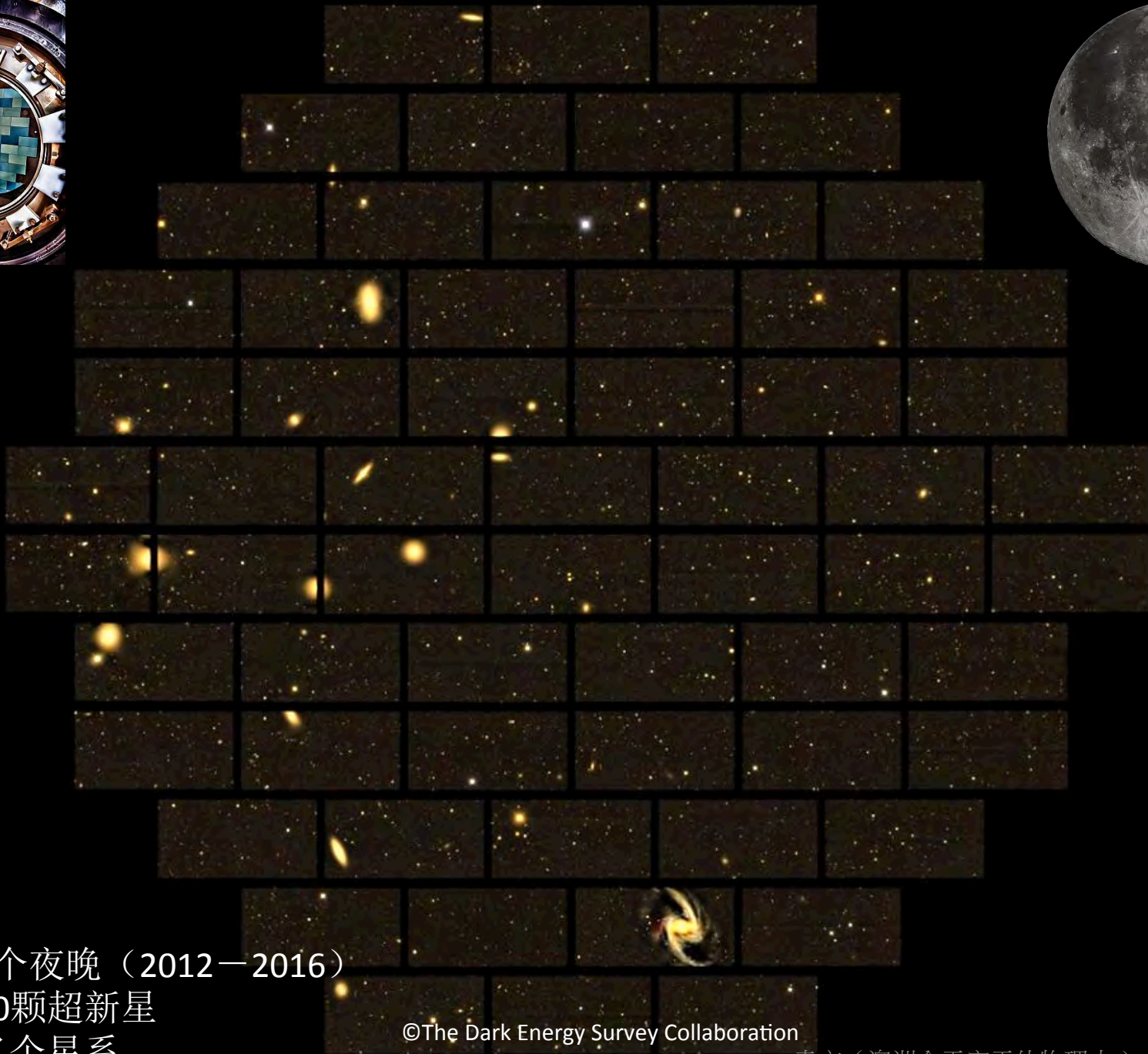
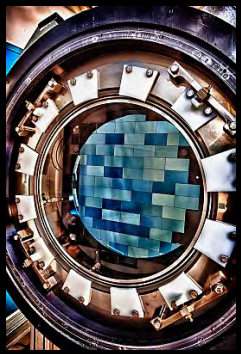






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袁方（澳洲全天空天体物理中心，澳洲国立大学）



- 525个夜晚（2012—2016）
- 3000颗超新星
- 三亿个星系

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zDES

DECam Data © The Dark Energy Survey Collaboration

- 100个夜晚（2013—2017）
- 数万个光谱
- 数万个红移
- 超新星，星系，类星体，白矮星



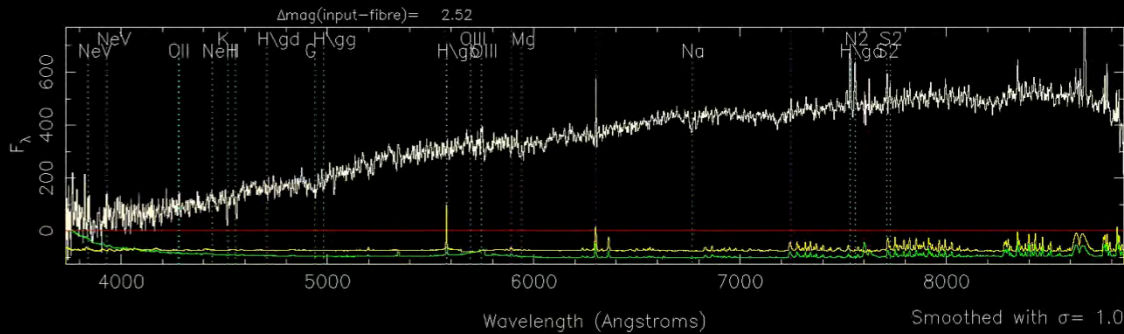
zDES

DECam Data © The Dark Energy Survey Collaboration

- 100个夜晚（2013—2017）
- 数万个光谱
- 数万个红移
- 超新星，星系，类星体，白矮星

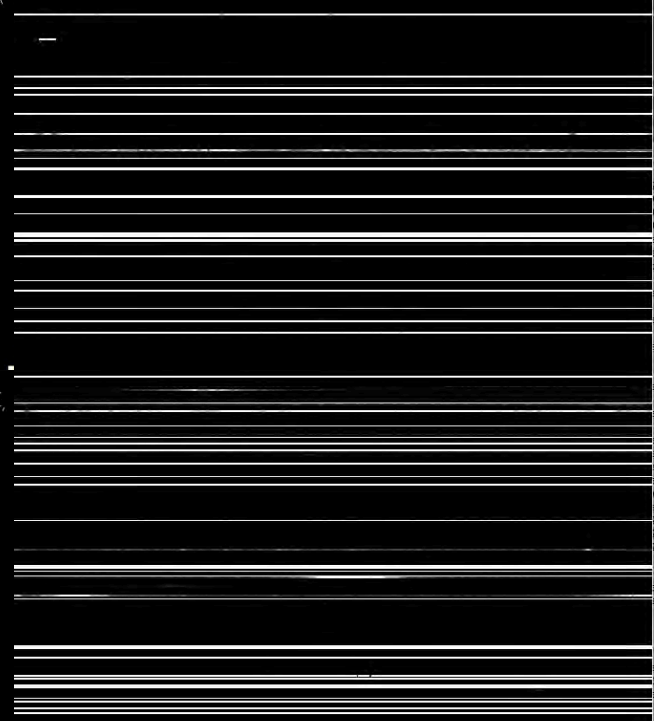
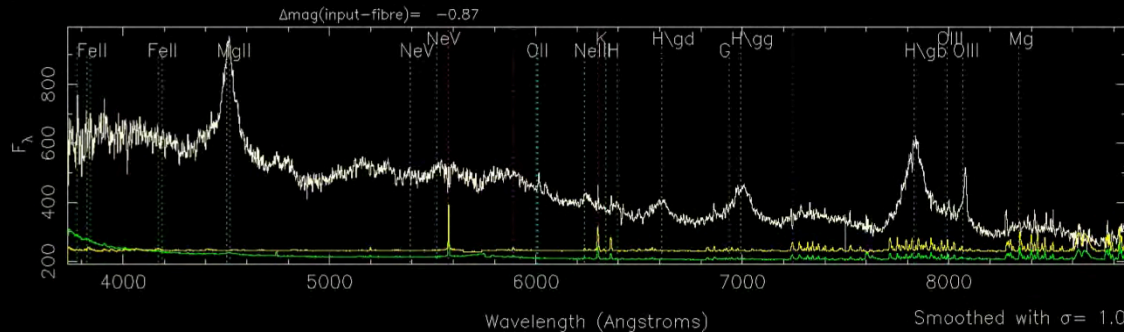
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袁方（澳洲全天空天体物理中心，澳洲国立大学）




 **Fermilab** — The Fermi National Accelerator Laboratory

 **Chicago** — The University of Chicago


 **NOAO** — The National Optical Astronomy Observatory

 United Kingdom DES Collaboration


- **UCL** - University College London
- **Cambridge** - University of Cambridge
- **Edinburgh** - University of Edinburgh
- **Portsmouth** - University of Portsmouth
- **Sussex** - University of Sussex
- **Nottingham** - University of Nottingham

 DES-Brazil Consortium

 **OSU** — The Ohio State University

 **TAMU** — Texas A&M University

Munich—Universitäts-Sternwarte München

-  **Ludwig-Maximilians Universität**
-  **Excitement Cluster Universe**


 **UIUC/NCSA** — The University of Illinois at Urbana-Champaign


 **LBLN** — The Lawrence Berkeley National Laboratory

 Spain DES Collaboration

- **IEEC/CSIC** - Instituto de Ciencias del Espacio,
- **IFAE** - Institut de Física d'Altes Energies
- **CIEMAT** - Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas

 **Michigan** — The University of Michigan

 **Pennsylvania** — The University of Pennsylvania

 **ANL** — Argonne National Laboratory

 Santa Cruz-SLAC-Stanford DES Consortium


- **Santa Cruz** - University of California Santa Cruz
- **SLAC** - SLAC National Accelerator Laboratory
- **Stanford** - Stanford University

 **ETH** — Eidgenössische Technische Hochschule Zürich

 **ETH-Zuerich** — Eidgenössische Technische Hochschule Zürich

 **Australian Astronomical Observatory**

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 **CSIRO Astronomy & Space Science (CASS)**

 **Macquarie University**

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 **Monash University**

 **The University of Queensland**

 **Swinburne University of Technology**

 **Sydney University**

- >120位科学家，23个研究机构，5个国家

- 24位研究人员，10个澳洲研究机构



http://www.mso.anu.edu.au/ozdes/public_ozdes.html

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还有问题？

- 随时问：

<http://rsaa.anu.edu.au/contact-us/ask-astronomer>