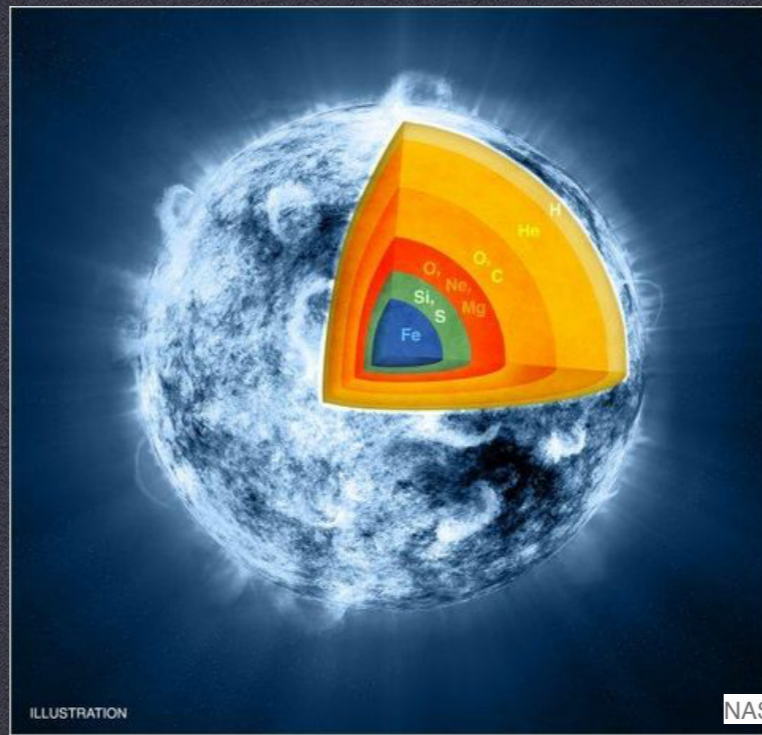
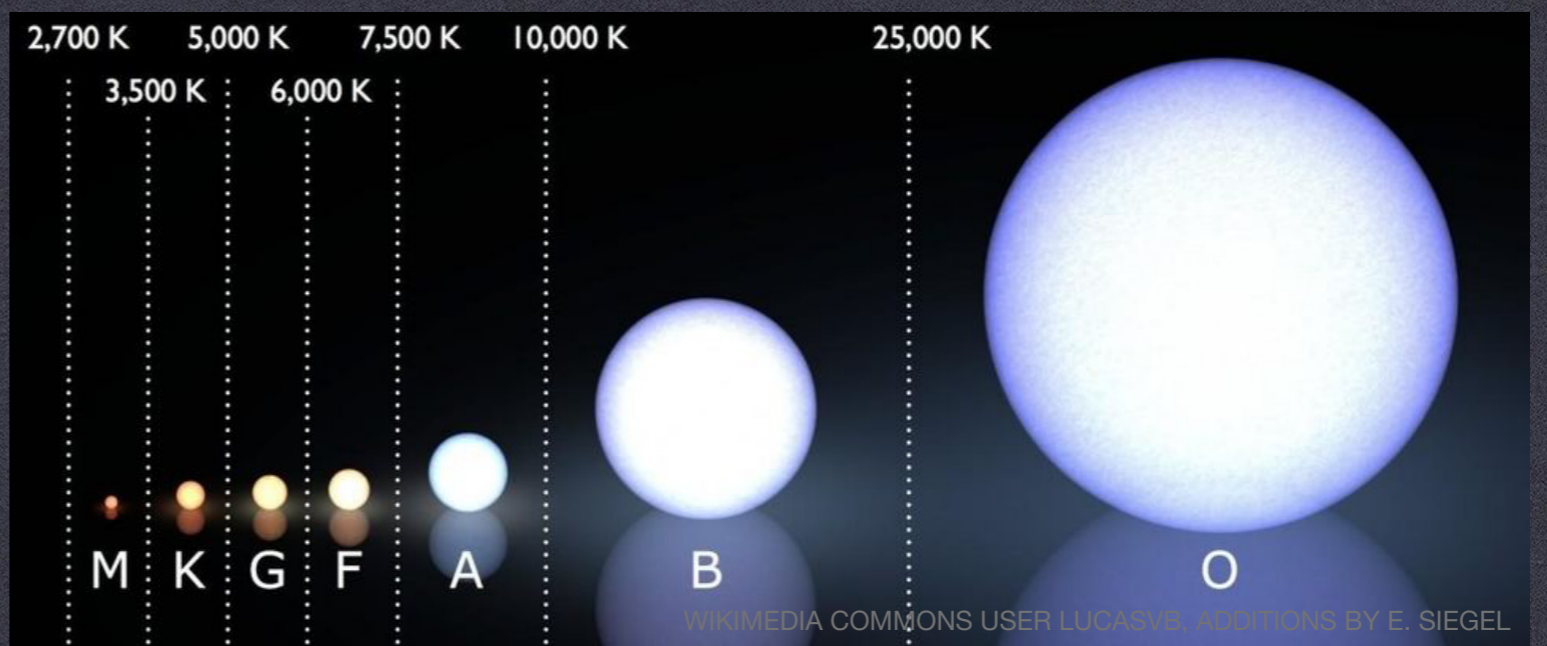
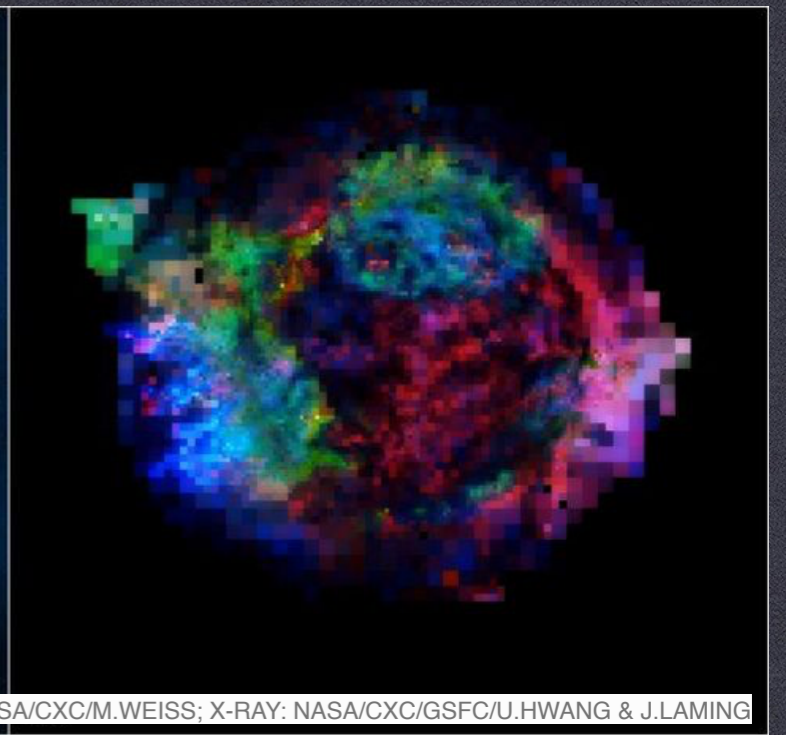


NASA'S GODDARD SPACE FLIGHT CENTER



ILLUSTRATION



NASA/CXC/M.WEISS; X-RAY: NASA/CXC/GSFC/U.HWANG & J.LAMING

黑洞质量缺口

BLACK HOLE MASS GAP

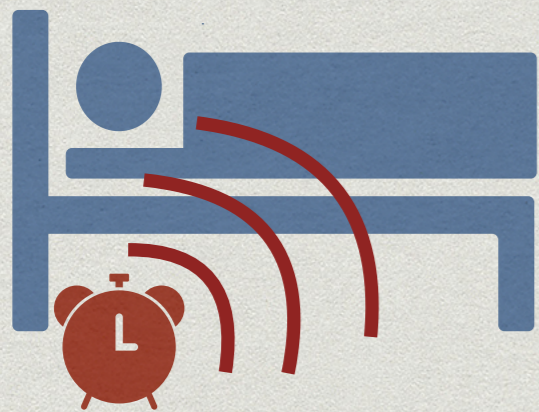
DATE 02/17

SPEAKER 纪璇 XUAN JI

DISTURBED NAPS AND BLACK HOLE MASS GAPS BY SUMEET KULKARNI

故事开始于.....

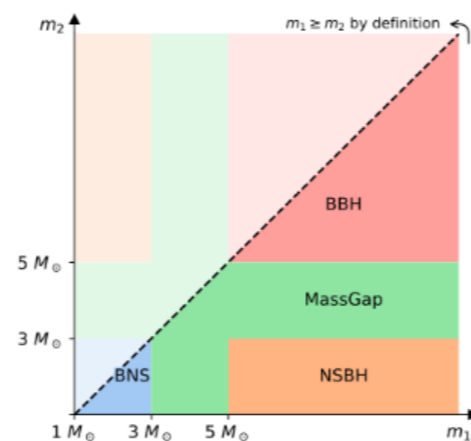
2019年9月24日



I'm someone who enjoys a sound sleep more than anything else, but I never complain when the universe calls.

新的引力波信号!

MassGap	>99%
Terrestrial	<1%
NSBH	0%
BNS	0%
BBH	0%

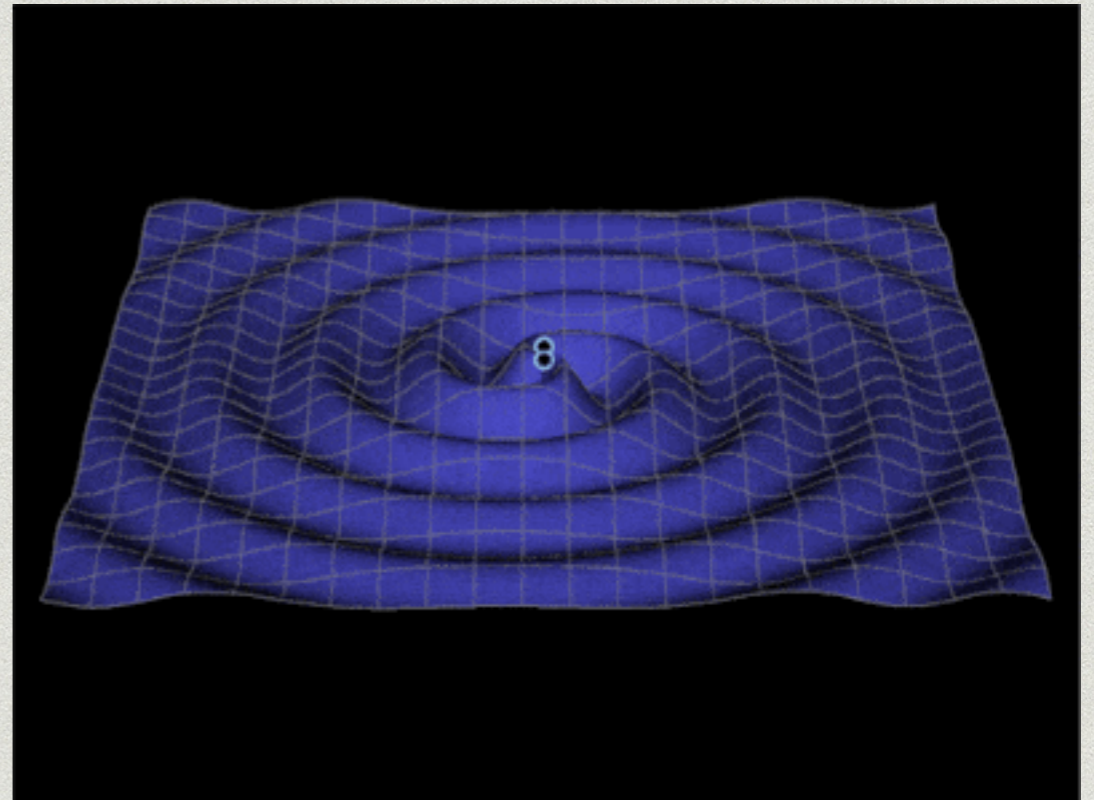


- * 来自何方的召唤?
- * 解读信号!

来自何方的召唤？

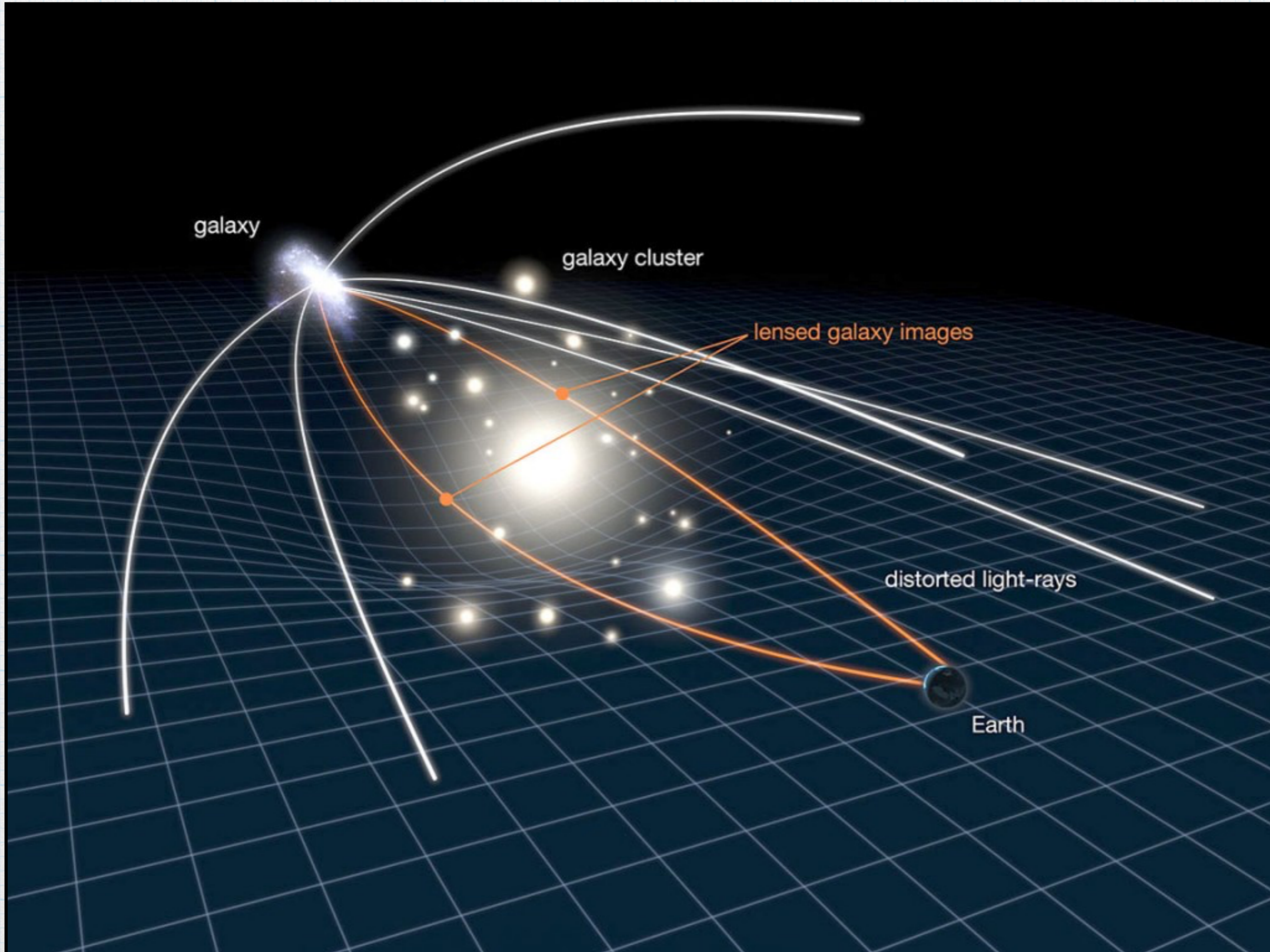
✦ 引力波！

广义相对论：质量会使空间发生弯曲



✦ 探测引力波：激光干涉仪

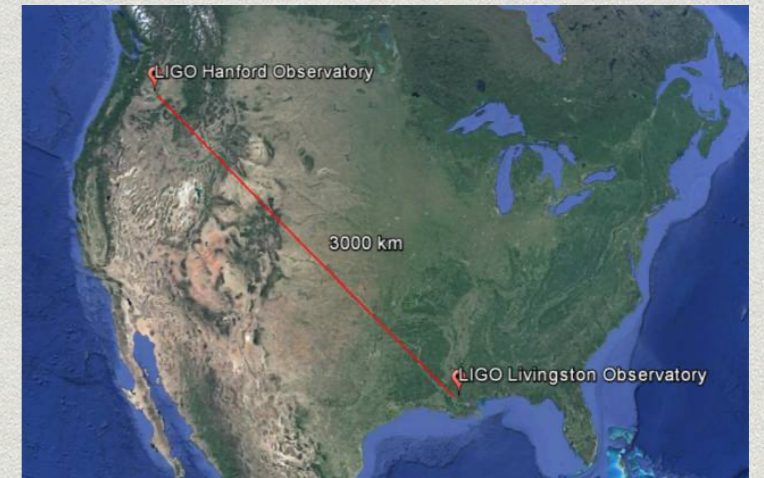
Microlensing



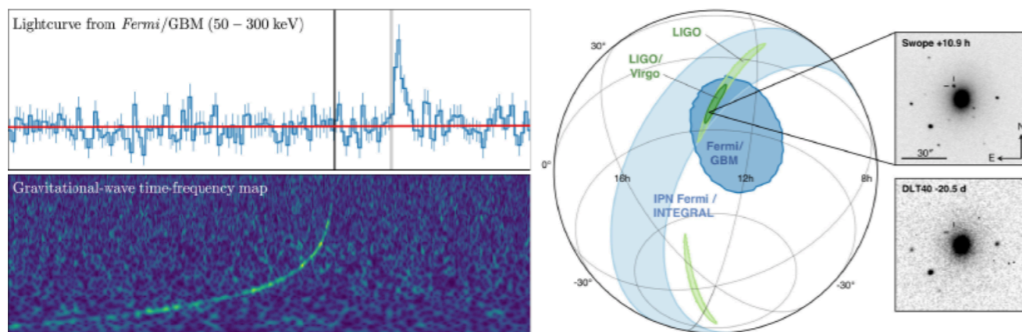
来自何方的召唤?

* 订阅引力波信号: <https://emfollow.docs.ligo.org/userguide/>

* IOS APP: <https://apps.apple.com/us/app/chirp-gravitational-wave-app/id1484328193>



LIGO/Virgo Public Alerts User Guide



Welcome to the LIGO/Virgo Public Alerts User Guide! This document is intended for both professional astronomers and science enthusiasts who are interested in receiving alerts and real-time data products related to gravitational-wave (GW) events.

Three sites (**LHO, LLO, Virgo**) together form a global network of ground-based GW detectors. The **LIGO Scientific Collaboration** and the **Virgo Collaboration** jointly analyze the data in real time to detect and localize transients from compact binary mergers and other sources. When a signal candidate is found, an alert is sent to astronomers in order to search for counterparts (electromagnetic waves or neutrinos).

Advanced LIGO and **Advanced Virgo** began their third observing run (O3) on April 1, 2019. For the first time, **LIGO/Virgo alerts are public**. Alerts are distributed through NASA's Gamma-ray Coordinates Network (**GCN**). There are two types of alerts: human-readable **GCN Circulars** and machine-readable **GCN Notices**. This document provides a brief overview of the procedures for vetting and sending GW alerts, describes their contents and format, and includes instructions and sample code for receiving GCN Notices and decoding GW sky maps.

LHO: LIGO Hanford, Washington, USA

LLO: LIGO Livingston, Louisiana, USA.



Virgo:意大利比萨



引力波信号警报!

* 探测后的几分钟内发出消息

A. 天文信号 or 地表噪音? (概率)

B. 如果是天文信号:

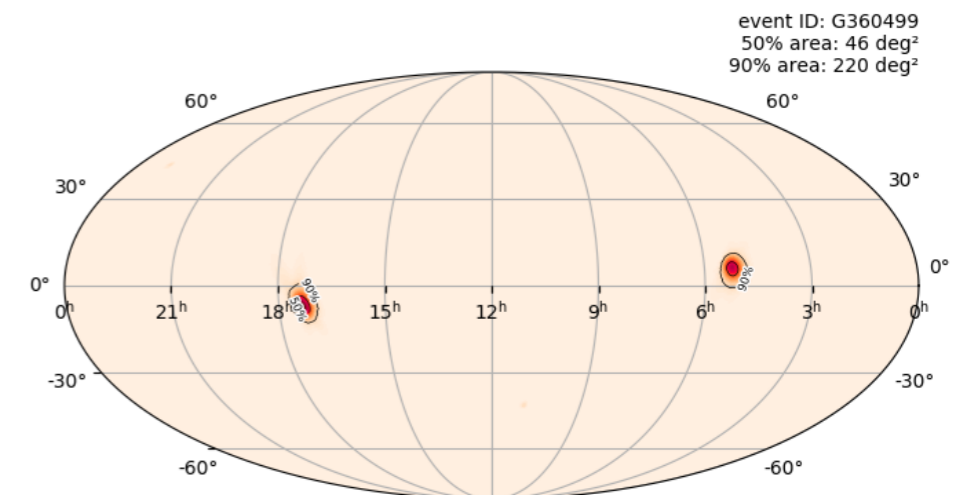
1. 双黑洞 Binary Black Holes (BBH)
2. 双中子星 Binary Neutron stars (BNS)
3. 中子星+黑洞 a neutron star and a black hole (NSBH)

LIGO/Virgo O3 Public Alerts

Detection candidates: 50

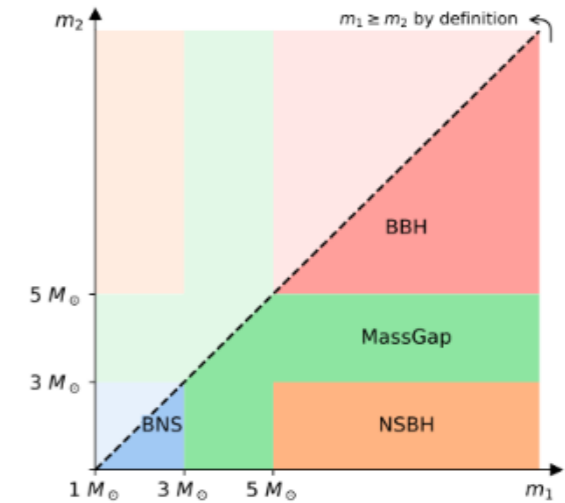
SORT: EVENT ID (A-Z) ▼

Event ID	Possible Source (Probability)	UTC	GCN	Location
S200213t	BNS (63%), Terrestrial (37%)	Feb. 13, 2020 04:10:40 UTC	GCN Circulars Notices VOE	
S200208g	BBH (99%)	Feb. 8, 2020 13:01:17 UTC	GCN Circulars Notices VOE	
S200129m	BBH (>99%)	Jan. 29, 2020 06:54:58 UTC	GCN Circulars Notices VOE	
S200128d	BBH (97%), Terrestrial (3%)	Jan. 28, 2020 02:20:11 UTC	GCN Circulars Notices VOE	



解读信号!

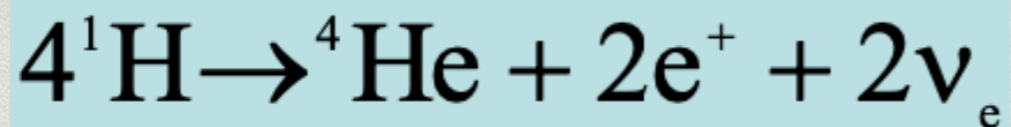
MassGap	>99%
Terrestrial	<1%
NSBH	0%
BNS	0%
BBH	0%



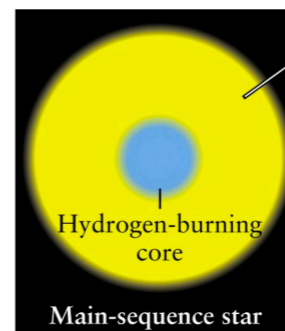
* 黑洞分类:

1. 原初黑洞 **Primordial Black Holes** have masses comparable to or less than that of the Earth. These purely hypothetical objects could have been formed through the gravitational collapse of regions of high **density** at the time of the **Big Bang**.
2. 恒星级黑洞 **Stellar Mass Black Holes** have masses between about 4 and 15 **solar masses** and result from the **core-collapse** of a massive **star** at the end of its life.
3. 中等质量黑洞 **Intermediate Mass Black Holes** of perhaps a few thousand **solar** masses may also exist. Sketchy evidence suggests that they may be found in some clusters of **stars**, and may eventually grow into **supermassive black holes**.
4. 超大质量黑洞 **Supermassive Black Holes** weigh between 10^6 and 10^9 solar masses and are found at the centres of most large **galaxies**.

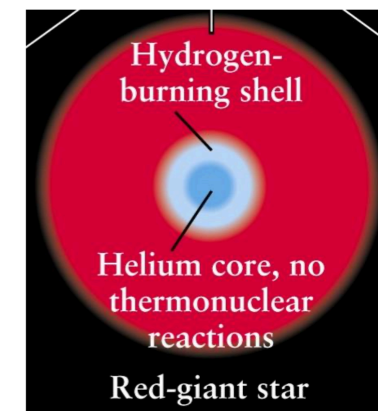
太阳的一生



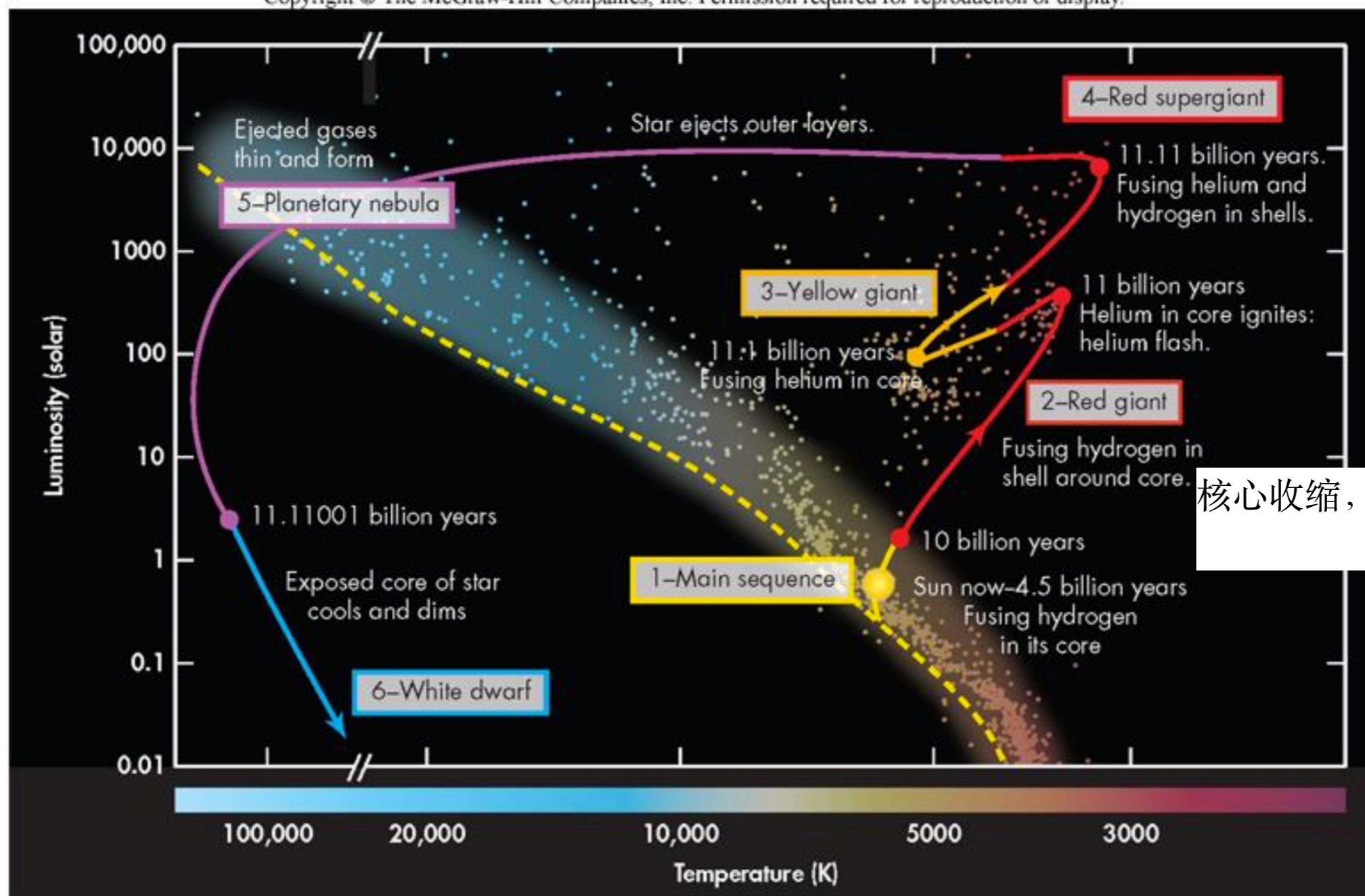
Sun today



Sun in ~10 Gyr



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核心收缩，外壳膨胀

大质量恒星的结局

> 8 太阳质量

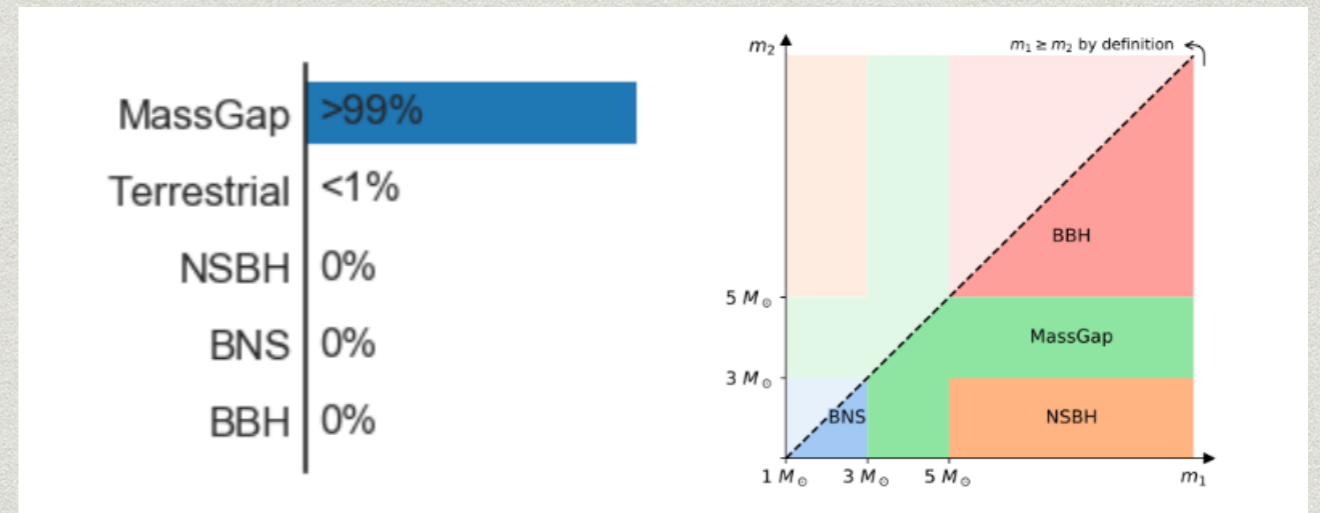
* 超新星爆炸

* 留下： 中子星 or 黑洞

* 理论上： 中子星质量可达 3 个太阳质量

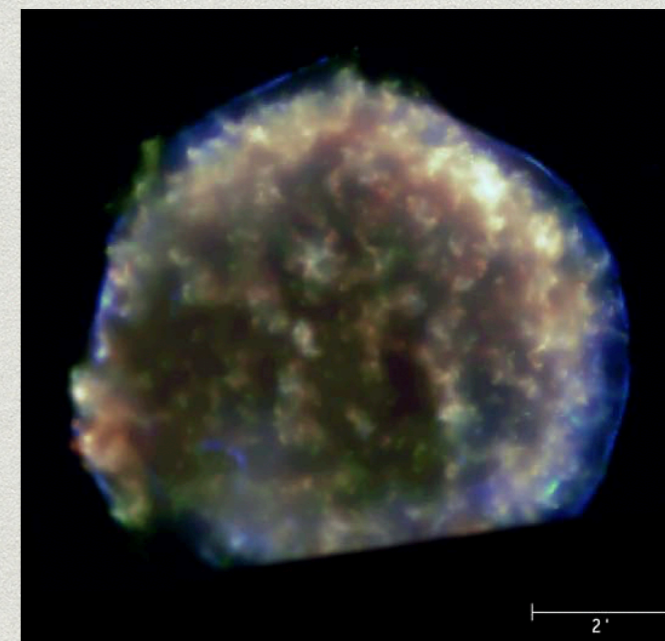
* 观测上： 最重中子星 ~ 2.14 solar mass

最轻黑洞 ~ 5 solar mass



MASS GAP: 3~5太阳质量

The Crab nebula -
optical (red) and X-
ray (lilac) composite



* 真正存在:

- 如何解释这一个发现?
- 理论修正?

* 假gap: 如何解释观测结果?

- 证据: 引力透镜效应 (GAIA)

