香港科學館 · 專題展覽 HONG KONG SCIENCE MUSEUM · SPECIAL EXHIBITION

趣味習作
Activity Sheet

教師指南
Teachers' Guide

Collider

世紀實驗：探索神秘的粒子世界

STEP INSIDE THE WORLD'S GREATEST EXPERIMENT

18.3 – 25.5.2016

聯合主辦 Jointly presented by
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蔡冠深基金會 Jonathan KS Choi Foundation

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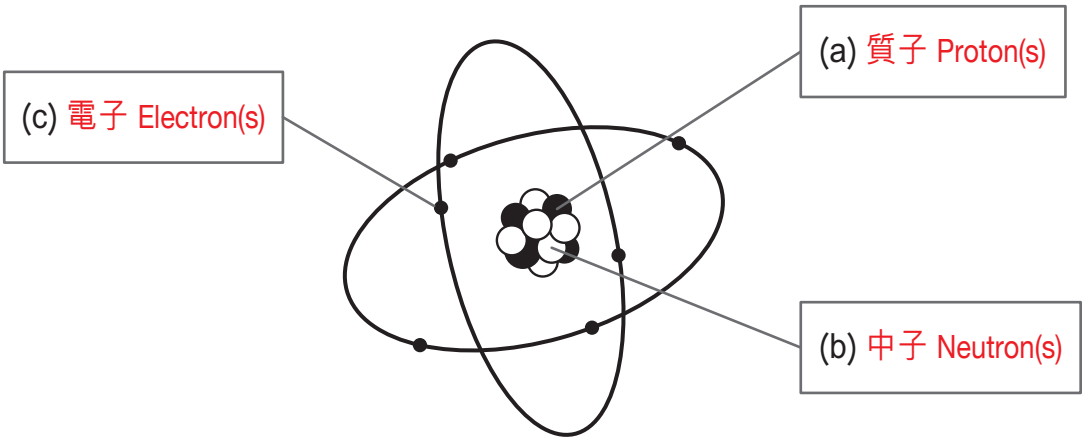
1. 甚麼是強子?
What are Hadrons?

請在空格內填上正確答案。
Please fill in the boxes with correct answers.

1. 所有物質都由原子構成。原子的中心是原子核，由帶正電荷的 (a) 和不帶電荷的 (b) 構成。環繞原子核運行的是帶負電荷的 (c) 。

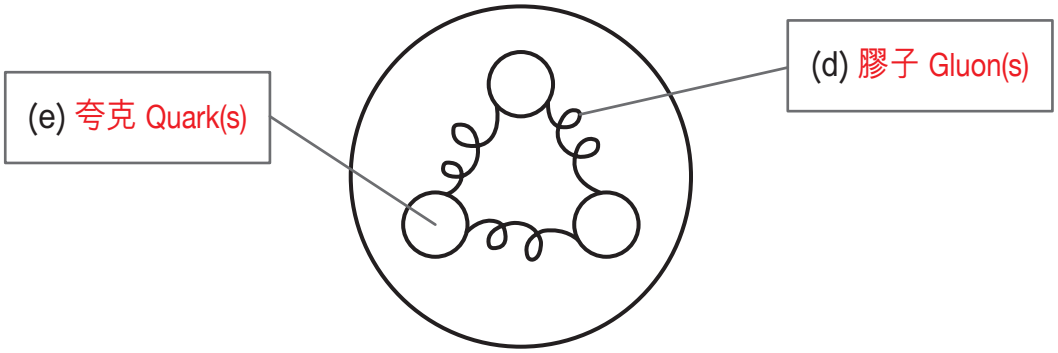
   Everything is made of atoms. At the centre of an atom is the nucleus. The nucleus consists of positively charged (a) and uncharged (b). Revolving round the nucleus are negatively charged (c).



原子 Atom

2. (a) 和 (b) 當中為更多更細由 (d) 「黏」在一起，名為 (e) 的粒子。所有由 (e) 組成的物質都稱為強子。(e) 互相緊扣的力非常強大，沒辦法解拆出一粒 (e) 作單獨研究。它們總會組合起來成為更大的粒子。

   Inside (a) and (b) are even smaller particles called (e), stuck together by (d). Things made of (e) are called hadrons. The force that binds (e) is so strong that it is impossible to study a (e) on its own. They always end up stuck together to form bigger particles.



強子 Hadron

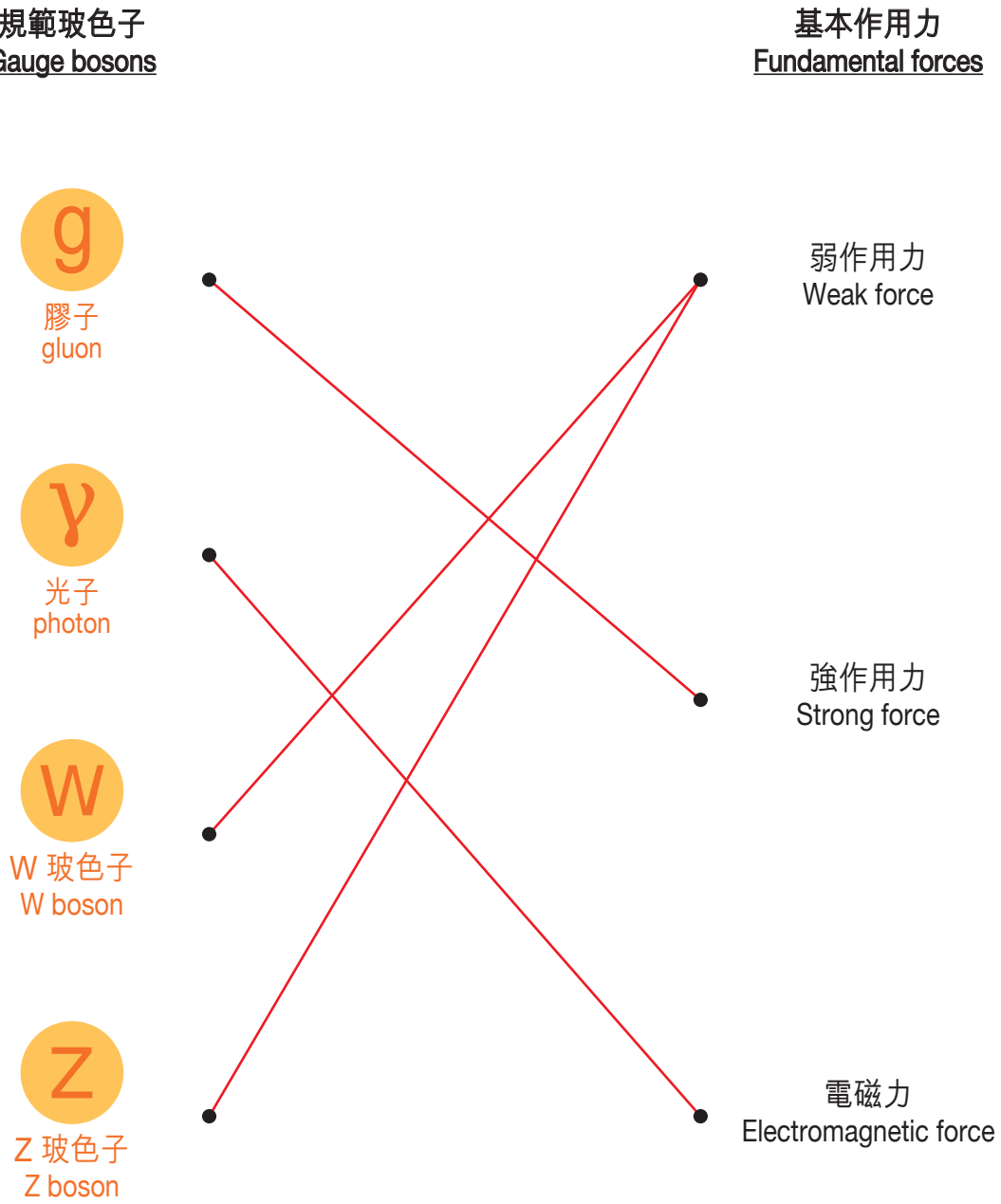
II. 標準模型
The Standard Model

3. 宇宙中的所有物質都是由被稱為基本粒子的基礎要素所構成，由四個基本作用力所支配。據現時我們對粒子物理學的認識，標準模型可以解釋基本粒子和其中三個基本作用力之間的關係。下面的標準模型尚未完成，你可以在空格內填上適當的粒子名稱來完成這個標準模型嗎?

Everything in the universe is found to be made from a few basic building blocks called fundamental particles, governed by four fundamental forces. From our understanding to particle physics, the Standard Model explains how these particles and three of the forces are related to each other. The Standard Model below is not yet completed. Can you finish it by filling in the blanks with correct particles?

4. 標準模型中，規範玻色子負責傳遞自然界的基本作用力，並使其他粒子可以相互影響。試把不同規範玻色子與其負責傳遞的基本作用力連接起來！

In the Standard Model, gauge bosons carry the forces of nature allowing other particles to interact. Please draw lines to link the gauge bosons with the corresponding forces.



5. 於2012年7月，歐洲核子研究組織(CERN)的物理學家透過大型強子對撞機(LHC)成功發現標準模型的最後一塊拼圖 —— 希格斯玻色子。試在展覽中找尋有關希格斯玻色子的資料，並在下面的空格內填上適當的答案。

In July 2012, the physicists of European Organization for Nuclear Research (CERN) successfully discovered the Higgs bosons, the last piece of puzzle of the Standard Model, using Large Hadron Collider (LHC). Please try to find the information of Higgs boson from the exhibition and fill in the following blanks.

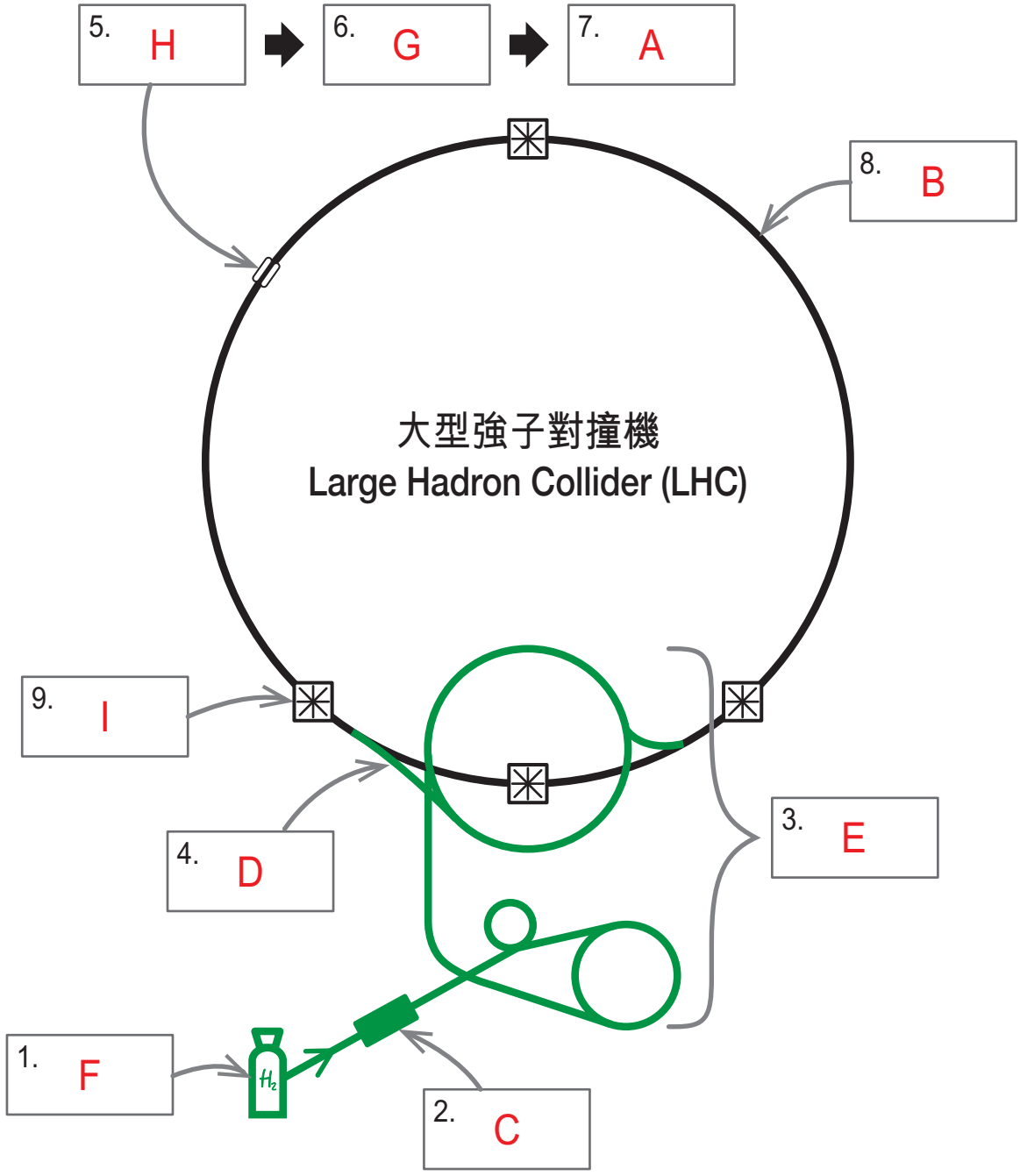
整個宇宙充滿着無形的場，稱為__希格斯場__。有些基本粒子和它有相互作用而獲得__質量__(好像電子)，其他的粒子(好像光子)則不會，因而__沒有質量__。
我們沒有辦法__看見__或觸摸到__希格斯場__，唯一的方法是在其中製造紛亂，好像在__空氣__中製造聲音。這干擾會以__粒子__形式出現，這就是__希格斯玻色子__。

There is an invisible field that fills the whole universe, called the __Higgs field__. Some fundamental particles interact with it and get __mass__ (like electrons), whereas others (like photons) do not and are __massless__.
We cannot __see__ or touch the __Higgs field__. The only way to know if it is there is to create a disturbance in it, like making a sound in __air__. This disturbance shows up as a __particle__, known as the __Higgs boson__.

III. 大型強子對撞機(LHC)如何運作?
How the Large Hadron Collider (LHC) Works?

6. 下圖是強子對撞機產生粒子束並將質子加速及互相碰撞的過程，請將後頁代表不同描述的英文字母按正確順序填入下圖中的方格內。

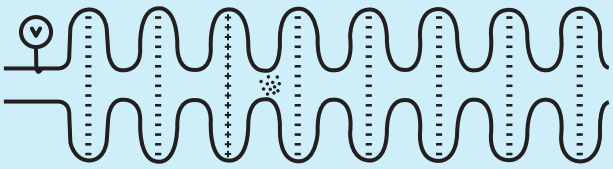
The diagram below shows how the LHC beams are made and protons are accelerated and collided. Please fill in the corresponding alphabets of the statements on the next pages to the boxes of the diagram.



A

電場正負極的轉換令質子加速。

The field flips between positive and negative accelerating the protons.



B

質子在大型強子對撞機內每秒繞轉11,000圈。

Protons circle the LHC 11,000 times per second.

C

質子穿過直線加速器。

The protons pass through a linear accelerator.

D

質子注入大型強子對撞機。

The protons are injected into the LHC.

E

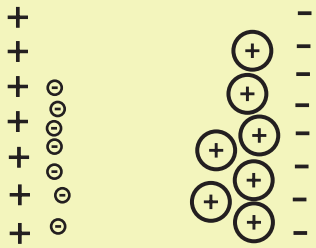
質子穿過質子同步推進器、質子同步加速器和超級質子同步加速器，令質子加速至光速的99.9998%。

The protons pass through the Proton Synchrotron Booster, the Proton Synchrotron and the Super Proton Synchrotron, accelerating to 99.9998% of the speed of light.

F

氫氣分子被電場撕開，製造出自由的質子和電子。

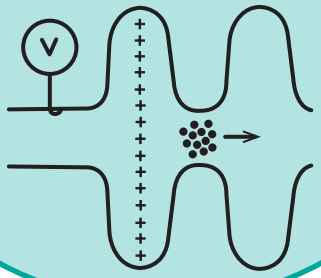
The hydrogen molecules are ripped apart by an electric field, creating free protons and free electrons.



G

電場由負極轉為正極，正極電場推動質子向前。

The field flips from negative to positive. The positive field pushes the protons forward.



H

質子束到達加速腔。負極電場拉動正電荷質子向前。

A bunch of protons arrives at the accelerating cavities. Positive protons are pulled forward by the negative electric field.

I

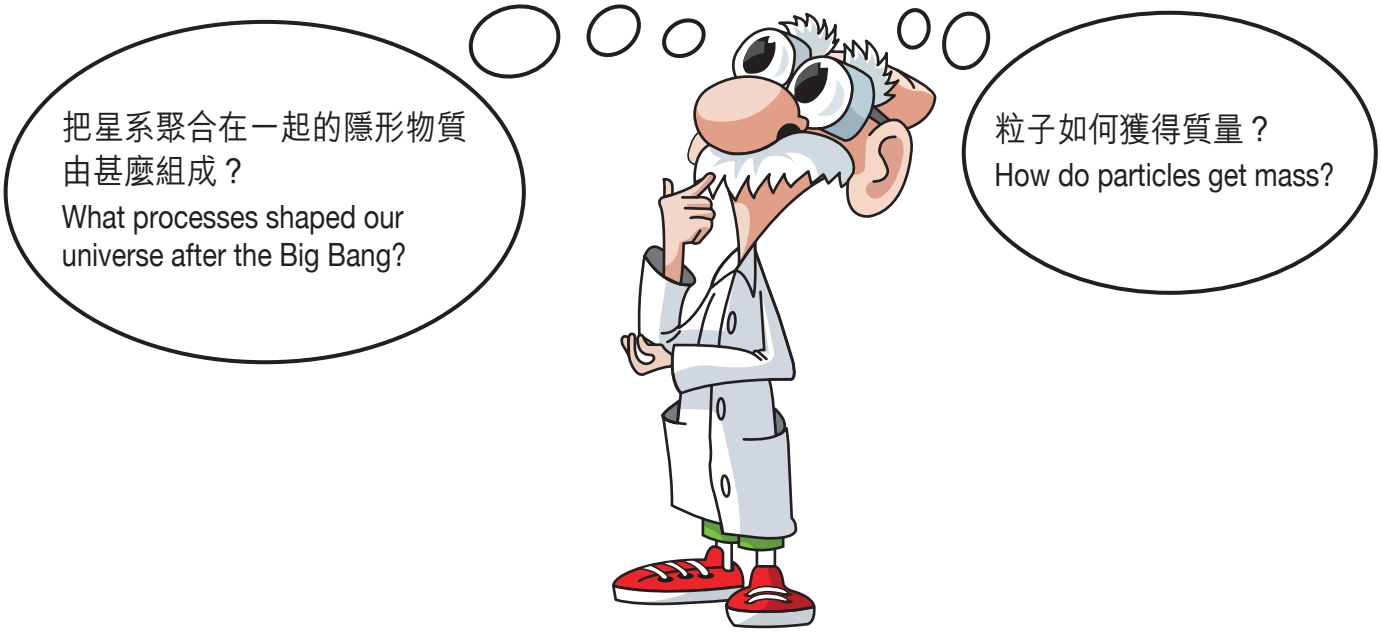
質子在探測器內互相碰撞，碰撞的能量會產生新的粒子，而當中有一些更是自宇宙在誕生的一瞬間以來，再未曾存在過。期望能藉這些新的粒子解開組成我們宇宙的基本結構之謎。

Protons collide within the detectors. From the energy of the collisions, new particles are born, some of which have not existed since the instant after our universe began. These new particles may be the key to uncover the fundamental building blocks of our universe.

IV. 強子對撞機的意念與實踐
LHC's Ideas and Experiments

7. 每天都有數以千計的物理學家忙於分析由大型強子對撞機實驗得出的龐大數據流，以尋找新粒子和現象的線索。為何物理學家對於大型強子對撞機如此着迷？ 他們研究的目的又是甚麼？ 試在展覽中找尋資料，並在下面的空格內填上適當的答案。

Thousands of physicists are busy analysing huge streams of data from the LHC's experiments every day, searching for hints of new particles or phenomena. Why physicists are fascinated by the LHC? What is the aim of their researches? Please try to find the information from the exhibition and fill in the following blanks.



大型強子對撞機的目的是__驗證__我們現有的理論，及探索__亞原子世界__的新領域。__理論__與__實踐__的相互影響對物理學的發展極為重要。利用數學語言演譯的理論能夠__解釋__在自然界所觀察到的事物，並可__預測__新事物。探測器接收到意想不到的訊號和不似預期的數據，可能揭示理論上的__漏洞__，並引領我們更全面了解宇宙的奧秘。

The Large Hadron Collider is built to __test__ our current theories and explore new regions of the __subatomic world__. This interplay between __theory__ and __experiment__ is crucial to the development of physics. Theories, written in the language of mathematics, can __explain__ existing observations and __predict__ new things about the physical world. Unexpected signals in a detector, or measurements that disagree with predictions, can reveal __gaping holes__ in theories, and point the way to a fuller understanding of the universe.