**The Chinese University of Hong Kong**
**Faculty of Science**
**Science Academy for Young Talent**

Summer Courses 2019
Course Schedule

# *CUSA1045 Discovering the Universe*
# *探索宇宙*

**Introduction:**

Humans want to explore the universe by looking up into the sky since ancient times. This course offers the outline about the selected phenomena which were observable with the naked eye. Upon finishing the course, students will acquire the development of modern astronomy, knowledge of the basic observational features of the sky, and the application of physical principles to astronomy.

The course includes lectures, experiments, and observation sessions. The experiments session is aimed to provide students with hand-on experience in basic physical principles and ideas in Astronomy. Student will have indoor observation of simulated night in class. Outdoor solar observation will be held if weather permits.

人類自古以來已希望通過觀察天文現象來探索身處的宇宙。本課程的設計正旨在概述這些肉眼能見的天象。完成課程的學生會了解當代天文的發展、有關天象的基本知識，以及物理定律在天文學上的應用。

本課程分為講座、實驗，和天文觀察三部份。實驗部份的目的是讓學生有機會親身驗證認識基本科學原理和天文概念。學生在天文觀察部份，可以參與模擬星空觀察。若天氣許可，學生會於室外作太陽的觀察。

**Medium of Instruction:** Cantonese supplemented with English

**Organising Unit:**
Department of Physics, Faculty of Science, CUHK

**Teacher:**
Dr. LEUNG Po Kin
Department of Physics, CUHK
Rm. 220, Science Centre North Block, CUHK
Tel: 3943 4078, E-mail: pkleung@phy.cuhk.edu.hk

**Demonstrators:**
Students from Department of Physics, CUHK

**Course Content:**

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| 10 August 2019<br>(Saturday)<br><br>9:00 am – 1:00 pm<br>2:00 pm – 5:00 pm | **<u>Lecture 講課:</u> (3 hrs)**<br>• Introduction to Astronomy<br>天文學簡介<br>• Ancient Greek Astronomy (Plato, Aristotle)<br>古希臘天文（柏拉圖、阿里士多德）<br>• Modern Astronomy (Copernicus, Kepler, Newton)<br>現代天文（哥白尼、開普勒、伽利略、牛頓）<br>• Newton's laws of motion and law of gravitation<br>牛頓運動定律和重力定律<br>• Basics concepts of celestial sphere<br>天球介紹<br>**<u>Assessment 評核:</u>**<br>• MC, short questions, etc 選擇題、短題目……<br><br>**<u>Lab 實驗:</u> (3 hrs)**<br>• Newtonian mechanics (Measuring gravitational acceleration; If time permits, also verifying Newton's second law.)<br>牛頓力學（例如：量度地心引力加速、確認牛頓運動定律）<br>**<u>Assessment 評核:</u>**<br>• Lab report 實驗報告<br><br>**<u>Observation 天文觀察:</u> (1 hr)**<br>• Indoor simulated night sky observation 室內模擬星空觀察 |
| 17 August 2019<br>(Saturday)<br><br>9:00 am – 1:00 pm<br>2:00 pm – 5:00 pm | **<u>Lecture 講課:</u> (3 hrs)**<br>• Constellations 星座<br>• Seasons 季節<br>• The Moon 月球（月相、潮汐、掩蝕）<br><br>**<u>Lecture 講課:</u> (2 hrs)**<br>• Overview of the Solar System 太陽系概覽<br>• Planets 行星<br>• Dwarf planets and asteroids 矮行星和小行星<br>• Comets 彗星<br>• Meteors 流星<br>**<u>Assessment 評核:</u>** MC, short questions, etc 選擇題、短題目……<br><br>**<u>Observation 天文觀察:</u> (2 hrs)**<br>(note: this session would be moved to the 3rd day in case of bad weather 若天氣欠佳，此部份將順延到第三天)<br>• Basics related to observation<br>有關天文觀察的基本知識<br>• Physical principles behind telescope<br>望遠鏡的原理<br>• Outdoor solar observation (if weather permits)<br>（如天氣許可）室外太陽觀察 |

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| 24 August 2019<br>(Saturday)<br><br>9:00 am – 1:00 pm<br>2:00 pm – 5:00 pm | **Lecture 講課: (3 hrs)**<br>• The Sun－the nearest star 太陽 － 最接近的恆星<br>• Stars 恆星<br>• Star light 星光<br><br>**Lab 實驗: (3 hrs)**<br>• Light (Spectrum of light; Demonstration of the difference of umbra and penumbra if time permits.)<br>光（例如：觀察原素光譜、確認玻爾模型及測量光速）<br>**Assessment 評核:** Lab report 實驗報告<br><br>**Lecture 講課: (1 hr)**<br>• Conclusion<br>總結<br>• Brief introduction to other fields in Astronomy<br>其他天文學範疇概覽<br>**Assessment 評核:** MC, short questions, etc 選擇題、短題目…… |
| 31 August 2019*<br>(Saturday)<br><br>9:00 am – 1:00 pm<br>2:00 pm – 5:00 pm | Makeup class<br>補課 |

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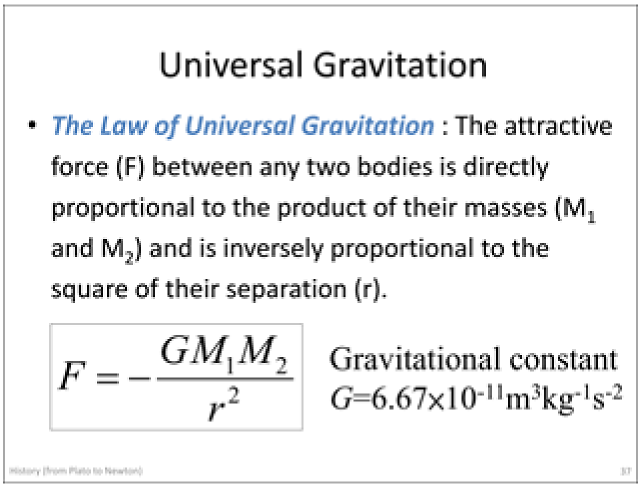
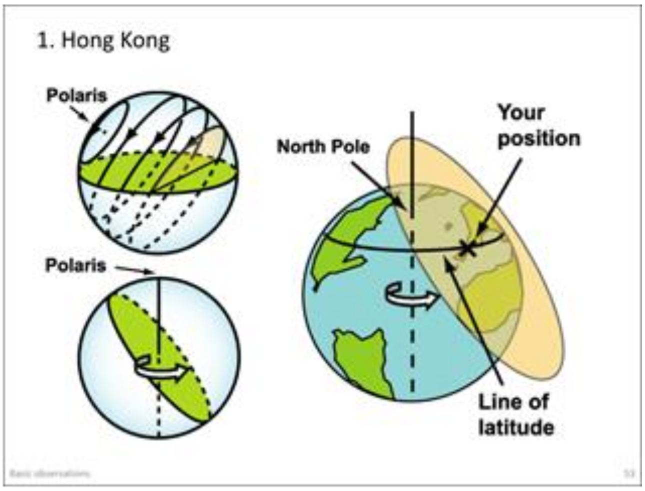
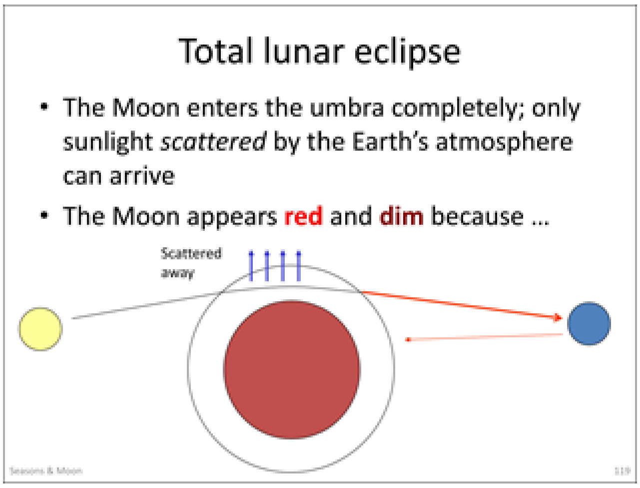
| **Duration** | 3 whole day sessions (total 21 contact hours) |
| **Date** | 10, 17, 24 August 2019<br>31 August 2019* (make-up class) |
| **Time** | 10, 17, 24 August 2019: 9:00 am – 1:00 pm; 2:00 pm – 5:00 pm<br>31 August 2019*: 9:00 am – 1:00 pm; 2:00 pm – 5:00 pm (make-up class) |
| **Venue** | The Chinese University of Hong Kong |
| **Enrollment** | 30 |
| **Expected applicants** | Students who are promoting to or studying S4-S6 |
| **Tuition Fee** | HKD 3,300.00 (including materials for experiments) |
| **Credit** | 1.5 Academy Unit<br>Certificates or letters of completion will be awarded to students who attain at least 75% attendance. |

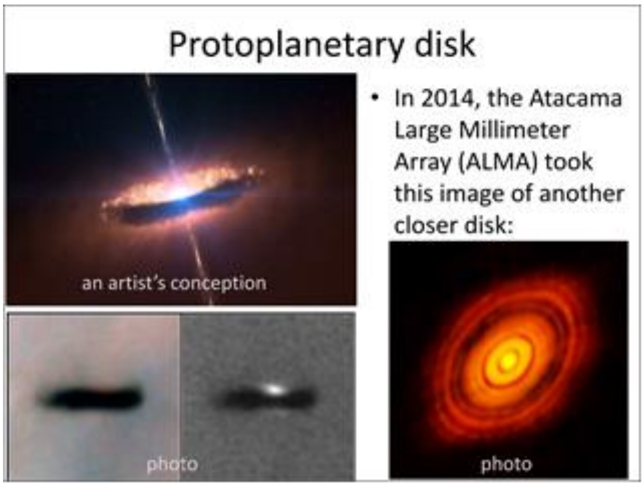
* This date is reserved for make-up classes in case there is any cancellation of classes due to bad weather or other factors.

Sample of lecture notes from previous years:

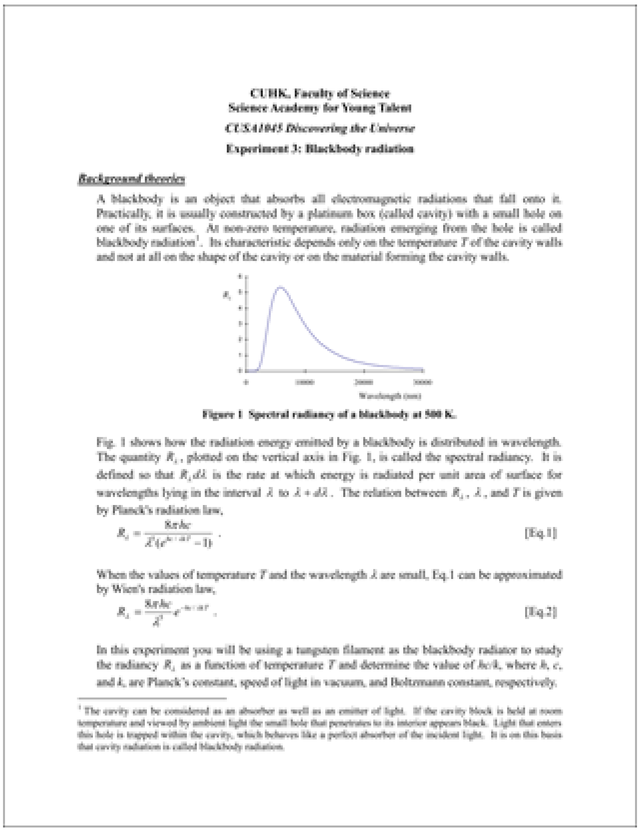



Sample of lab manuals from previous years:



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**Experiment 3: Blackbody radiation**

***Background theories***

A blackbody is an object that absorbs all electromagnetic radiations that fall onto it. Practically, it is usually constructed by a platinum box (called cavity) with a small hole on one of its surfaces. At non-zero temperature, radiation emerging from the hole is called blackbody radiation[1]. Its characteristic depends only on the temperature $T$ of the cavity walls and not at all on the shape of the cavity or on the material forming the cavity walls.

**Figure 1 Spectral radiancy of a blackbody at 500 K.**

Fig. 1 shows how the radiation energy emitted by a blackbody is distributed in wavelength. The quantity $R_\lambda$, plotted on the vertical axis in Fig. 1, is called the spectral radiancy. It is defined so that $R_\lambda d\lambda$ is the rate at which energy is radiated per unit area of surface for wavelengths lying in the interval $\lambda$ to $\lambda + d\lambda$. The relation between $R_\lambda$, $\lambda$, and $T$ is given by Planck's radiation law,

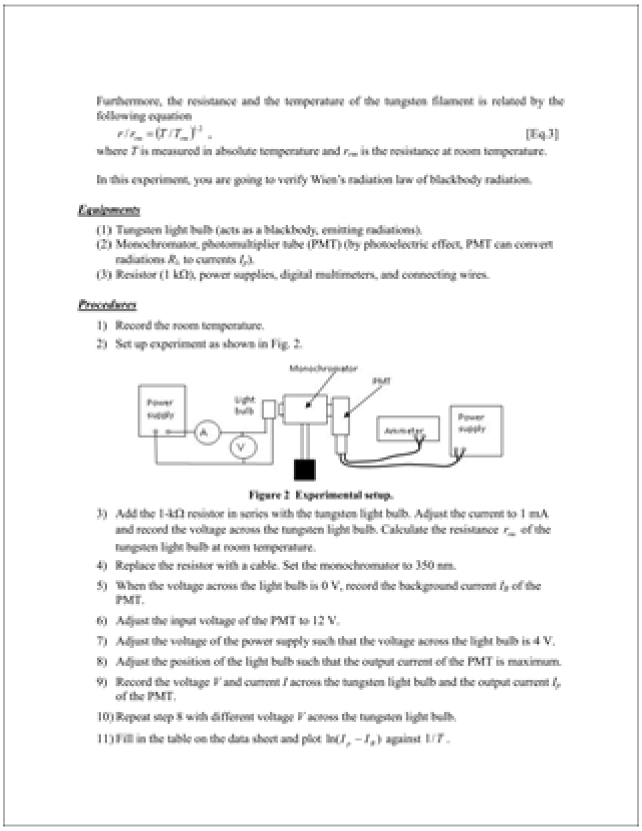
$$R_\lambda = \frac{8\pi hc}{\lambda^5 (e^{hc/\lambda kT} - 1)} . \quad \text{[Eq.1]}$$

When the values of temperature $T$ and the wavelength $\lambda$ are small, Eq.1 can be approximated by Wien's radiation law,

$$R_\lambda = \frac{8\pi hc}{\lambda^5} e^{-hc/\lambda kT} . \quad \text{[Eq.2]}$$

In this experiment you will be using a tungsten filament as the blackbody radiator to study the radiancy $R_\lambda$ as a function of temperature $T$ and determine the value of $hc/k$, where $h$, $c$, and $k$, are Planck's constant, speed of light in vacuum, and Boltzmann constant, respectively.

[1] The cavity can be considered as an absorber as well as an emitter of light. If the cavity block is held at room temperature and viewed by ambient light the small hole that penetrates to its interior appears black. Light that enters this hole is trapped within the cavity, which behaves like a perfect absorber of the incident light. It is on this basis that cavity radiation is called blackbody radiation.



Furthermore, the resistance and the temperature of the tungsten filament is related by the following equation

$$r/r_{rm} = (T/T_{rm})^{1.2} , \quad \text{[Eq.3]}$$

where $T$ is measured in absolute temperature and $r_{rm}$ is the resistance at room temperature.

In this experiment, you are going to verify Wien's radiation law of blackbody radiation.

***Equipments***

(1) Tungsten light bulb (acts as a blackbody, emitting radiations).
(2) Monochromator, photomultiplier tube (PMT) (by photoelectric effect, PMT can convert radiations $R_\lambda$ to currents $I_p$).
(3) Resistor (1 kΩ), power supplies, digital multimeters, and connecting wires.

***Procedures***

1) Record the room temperature.
2) Set up experiment as shown in Fig. 2.

Monochromator
PMT
Power supply
Light bulb
A
V
Ammeter
Power supply

**Figure 2 Experimental setup.**

3) Add the 1-kΩ resistor in series with the tungsten light bulb. Adjust the current to 1 mA and record the voltage across the tungsten light bulb. Calculate the resistance $r_{rm}$ of the tungsten light bulb at room temperature.
4) Replace the resistor with a cable. Set the monochromator to 350 nm.
5) When the voltage across the light bulb is 0 V, record the background current $I_B$ of the PMT.
6) Adjust the input voltage of the PMT to 12 V.
7) Adjust the voltage of the power supply such that the voltage across the light bulb is 4 V.
8) Adjust the position of the light bulb such that the output current of the PMT is maximum.
9) Record the voltage $V$ and current $I$ across the tungsten light bulb and the output current $I_p$ of the PMT.
10) Repeat step 8 with different voltage $V$ across the tungsten light bulb.
11) Fill in the table on the data sheet and plot $\ln(I_p - I_B)$ against $1/T$.