star Vega in night sky

# *Welcome to PHAS 1102 "Physics of the Universe"*

Dr. Daisuke Kawata
(UCL Department of Space and Climate Physics)
and
Prof. Ian Howarth
(UCL Department of Physics and Astronomy)

# Attendance Sheet...

- Please sign the sheet passed around.
- If your name is not on the list, please add YOUR NAME, DEPARTMENT, DEGREE COURSE (CAPITAL LETTER) on an empty line at the end of the form
- Attendance form to be signed at each lecture.

# PHAS 1102, Physics of the Universe

- 3 hours lectures a week over 10 weeks
  (first 5 weeks by Kawata, 2nd half by Prof. Howarth)
- "Reading week" ( Nov 9-13)
- Mon. 11-13 at Roberts 106
  Wed.  10 (sharp!)-11 at Harrie Massey LT
  check any change of schedule at
  http://www.mssl.ucl.ac.uk/~dka/phas1102/
- assessment: marked homework returned at tutorials.
  written exam in ~April

- Course Website entry page at
  http://zuserver2.star.ucl.ac.uk/~idh/PHAS1102/

- Lecture slides of first half can be found at
  http://www.mssl.ucl.ac.uk/~dka/PHAS1102/
  They show up after the lecture. So, please take your notes first, and use them for reference.

- Moodle PHAS1102 site on Moodle,
  entry code, ‘09P1102’
  https://moodle.ucl.ac.uk/login/index.php

# PHAS 1102, Physics of the Universe

## Approximate allocation of lectures

### Stellar Astrophysics

- Radiation, luminosity, effective temperature (3)
- Atomic structure and stellar spectra (2)
- Energy generation, nuclear fusion, solar neutrinos (3)
- Outline of stellar evolution, end points(4)

# PHAS 1102, Physics of the Universe

## Approximate allocation of lectures:

"Cosmology and the Universe" by Prof. Howarth

- Universe composition, galaxy and clusters (3)
- dark matter, dynamical mass, gravitational lensing (2)
- Hubble's law, extragalactic distance scale (3)
- 'World models', density parameter, geometry of space (2)
- The 'concordance model' (1)

# reading list

- Zeilik & Gregory, “Introductory Astronomy and Astrophysics (4th ed., Thomson Learning, 1998)
- Freedman & Kaufmann, “Universe” (8th ed., Freeman, 2008)

# Physical Unit

- This lecture use SI (or international system) unit length=m, mass=kg, time=sec
- In astronomy research, we commonly use “cgs” unit, cm, g, sec.

Myself...

Daisuke Kawata, based at
UCL Department of Space and Climate Physics
(Mullard Space Science Laboratory, MSSL)
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http://www.mssl.ucl.ac.uk/~dka/

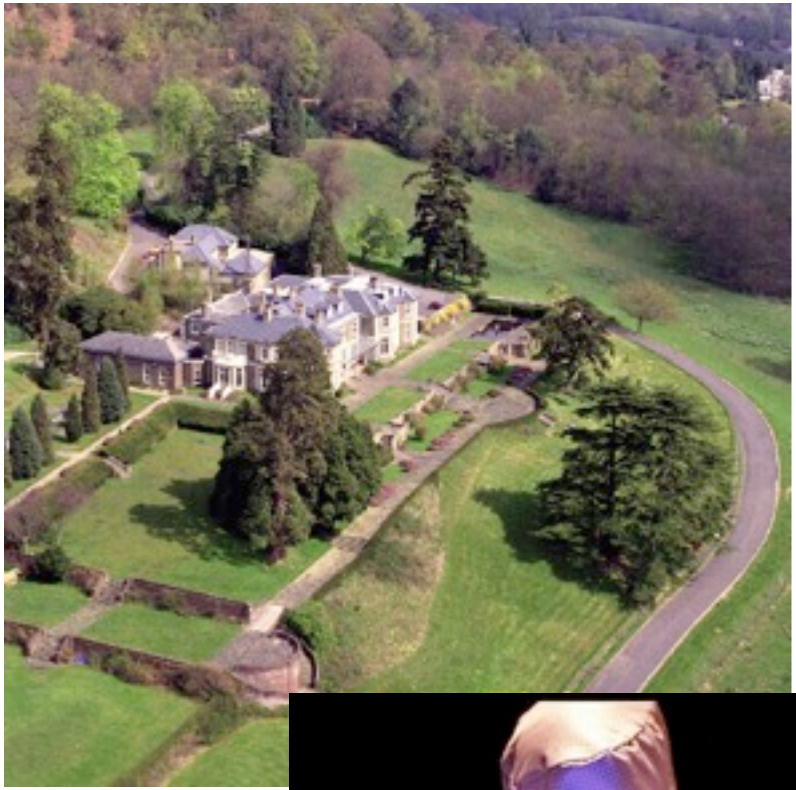
# Astronomy in UCL

- Physics & Astronomy at the main campus
- Space & Climate Physics
  (Mullard Space Science Laboratory, MSSL)
  at Surrey.

# Mullard Space Science Laboratory (MSSL)
# Holmbury St. Mary, Dorking, http://mssl.ucl.ac.uk

# Mullard Space Science Laboratory (MSSL)
## http://www.mssl.ucl.ac.uk

- Largest University Space Science Lab in the UK
- about 120 people on site.
- space projects with ESA, NASA, Japan, China, Russia, India...



XMM-Newton (1999, X-ray, ESA)

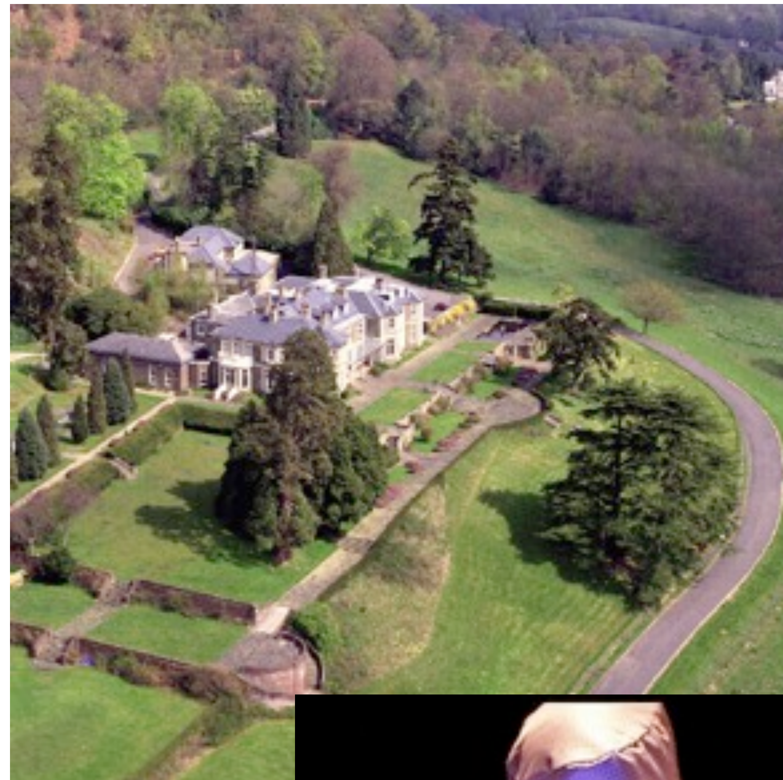
Hershel (2009, Infra-red, ESA)

Gaia (2012, Astrometry, ESA)

# Mullard Space Science Laboratory (MSSL)
# http://www.mssl.ucl.ac.uk

Internationally renowned research group

Astrophysics
Solar and stellar physics
Space plasma physics
Planetary science
Detector physics
Theory
Earth observation
Climate extremes



We will arrange a bus trip to MSSL
in reading week (Nov. 9-13).
Let me (d.kawata@ucl.ac.uk) know
if you are interested in.

# Stellar Astrophysics

Small Magellanic Cloud

Large Magellanic Cloud

Milky Way

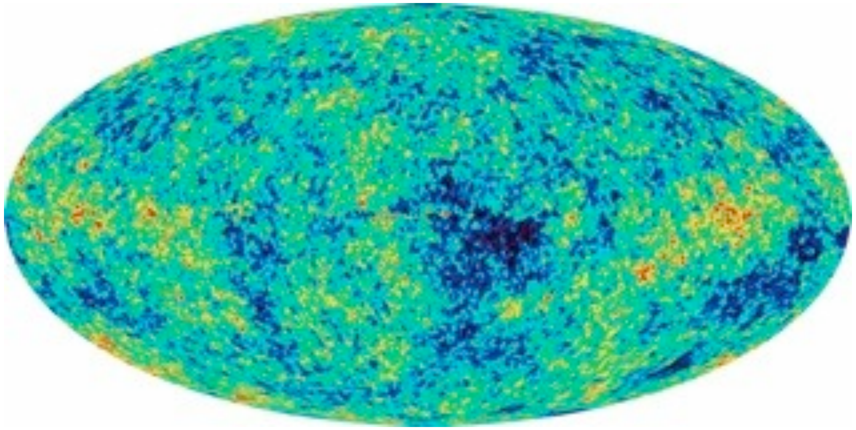
Southern Sky at Celo Tololo, CTIO 4 m Blanco Telescope

Andromeda Galaxy (M31)

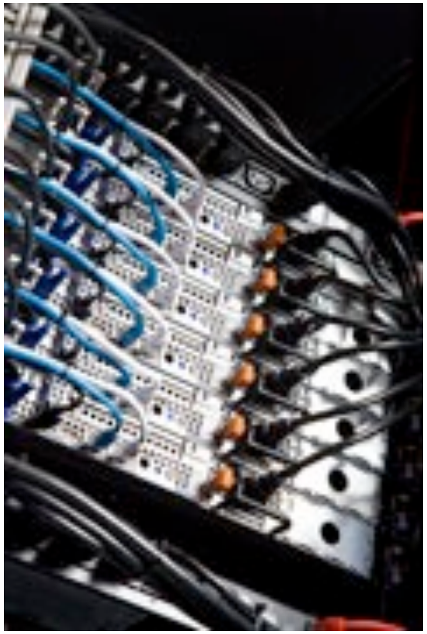
2MASS Showcase

**The Infrared Milky Way** This map of the infrared sky includes the light of a half billion stars

# My research: numerical simulations of galaxy formation



Universe's initial condition



Supercomputer
UCL, Legion cluster
(2560 cores)

# Stars

- Fundamental Component of the Universe
- Our Milky Way consists of more than $10^{10}$ stars
- Astronomer observe star light

# Physical units

A word about physical units: we shall tend to use **SI** (or **International System**) units, but note that most research papers employ **cgs** units!

Some units are specific to Astronomy, e.g.

1 Astronomical Unit (AU) = $1.50 \times 10^{11}$ m

1 light-year (ly) = $9.46 \times 10^{15}$ m

1 parsec (pc) = 3.26 ly = $3.09 \times 10^{16}$ m = 206,265 AU

1 Angstrom (A) = 0.1 nm = $10^{-4}$ $\mu$m = $10^{-10}$ m

1 eV = $1.6 \times 10^{-19}$ Joule

# Useful conversions

| Quantity | SI | cgs |
|---|---|---|
| Length | 1 m | 1 cm = $10^{-2}$ m |
| Time | 1 sec | 1 sec |
| Mass | 1 kg | 1 g = $10^{-3}$ kg |
| Frequency | 1 Hz | 1 Hz |
| Energy | 1 Joule | 1 erg = $10^{-7}$ Joule |
| Power | 1 Watt | $10^{-7}$ Watt |
| | 1 Joule $\sec^{-1}$ | 1 erg $\sec^{-1}$ |
| Force | 1 Newton | 1 dyne |
| | 1 Joule $m^{-1}$ | $10^{-5}$ Newton |
| Charge | 1 Coulomb | 1 esu |
| | | $3.3 \times 10^{-10}$ Coulomb |
| Magnetic flux density | 1 Tesla | 1 Gauss |
| | 1 Weber $m^{-2}$ | $10^{-4}$ Tesla |

# Physical constants

$G = 6.67 \times 10^{-11}$ m$^3$ kg$^{-1}$ sec$^{-2}$

$c = 3.00 \times 10^{8}$ m sec$^{-1}$

$e = 1.60 \times 10^{-19}$ Coulomb

$m_e = 9.11 \times 10^{-31}$ kg

$m_p = 1.67 \times 10^{-27}$ kg

$h = 6.63 \times 10^{-34}$ Joule sec (Planck constant)

$k = 1.38 \times 10^{-23}$ Joule K$^{-1}$ (Boltzmann constant)

$\sigma = 5.67 \times 10^{-8}$ Watt m$^{-2}$ K$^{-4}$ (Stefan-Boltzmann constant)

$\sigma_e = 6.65 \times 10^{-29}$ m$^2$ (Thomson cross-section for electron)

$M_{Sun} = 2 \times 10^{30}$ kg

$R_{Sun} = 7 \times 10^{8}$ m

**$L_{Sun}$ = 4 x $10^{26}$ Watt**

# Useful formulae

Kinetic energy: $E = \frac{1}{2} m v^2$

Newton's second law (conservation of momentum):

$$F = ma$$

Gravitational force between two masses $m_1$ and $m_2$:

$$F = G \frac{m_1 m_2}{r^2}$$

where $G$ is the gravitational constant

Acceleration of a particle moving in a circle: $a = \frac{v^2}{r}$

Coulomb's law: $F = \frac{q_1 q_2}{4 \pi \varepsilon_0 r^2}$

Force on a charge $e$ moving at speed $\underline{v}$ in a magnetic field $\underline{B}$:

$$\underline{F} = e \underline{v} \times \underline{B}$$

Energy-frequency relation: $E = h\nu$

Wavelength-frequency relation: $\lambda = \frac{c}{\nu}$