Magnetohydrodynamics

Counsel: **Tuesday & Thursday 11:30 - 13:00**

Office: **Room 532 in Bldg. of the College of Applied Sciences**

Homepage: **//solardynamicslab.khu.ac.kr/~magara**

Topics:

- **Brief introduction to plasma physics**
- **Derivation of MHD equations from Boltzmann equation**
- **Shock waves**
- **MHD instabilities**
- **Magnetic reconnection**

Lecture characteristics:

Theory: 60%, Practical Training: 40%

Instruction method:

Discussion, Audi-visual Education, Presentation

Evaluation method:

Mid-term Exam... 30%, Final Exam... 30%, Homework/Report... 30%, Attendance... 10%

Textbooks:

- Solar Magnetohydrodynamics (E.R. Priest, D. Reidel Publishing Company, 1984, 9789027718334)
- Introduction to Plasma Physics and Controlled Fusion (Francis F. Chen, Springer, 1984, 9780306413322)
- Plasma Physics (Peter Andrew Sturrock, Cambridge University Press, 1994, 9780521448109)
- Gas dynamics (Frank H. Shu, Univ. Science Books, 1992, 9780935702651)

Assignments:

Each student should submit a report, in addition to taking mid-term and final exams.

What is plasma?

Plasma...

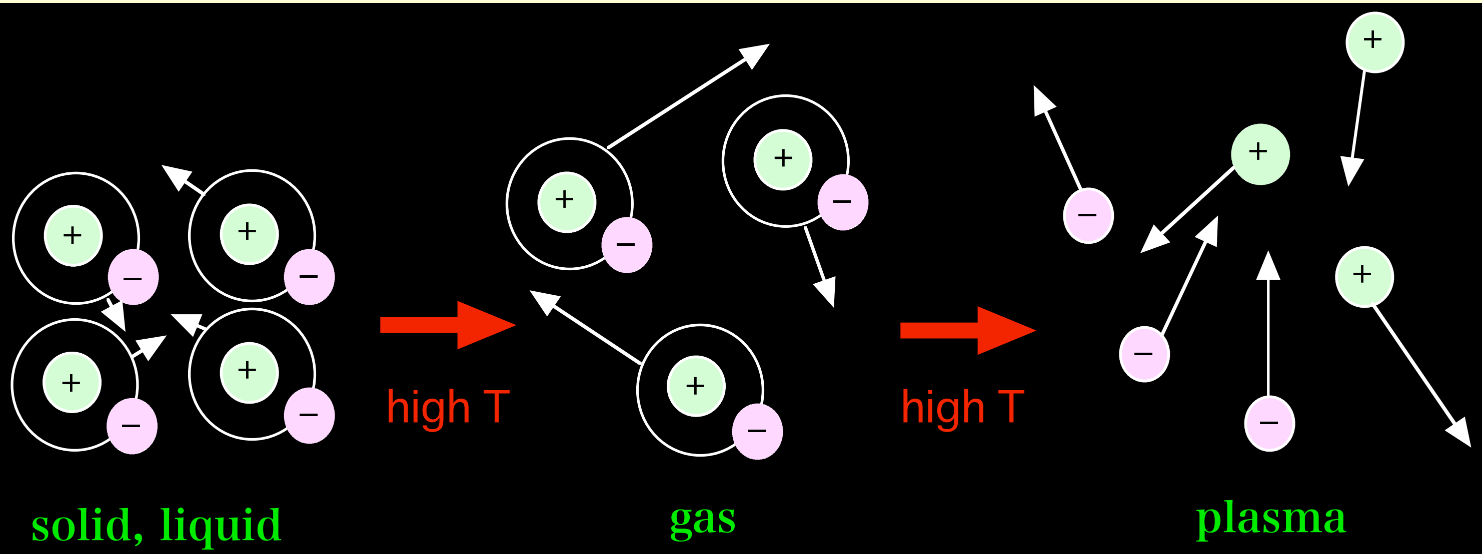
the 4th-state of matter, following solid, liquid, and gas

High temperature ($T \geq 10^4$ K)

→ neutral particles are dissociated into positive ions and negative electrons (ionization)

↓

plasma



Two types of plasma

Cold plasma (partially ionized plasma)...

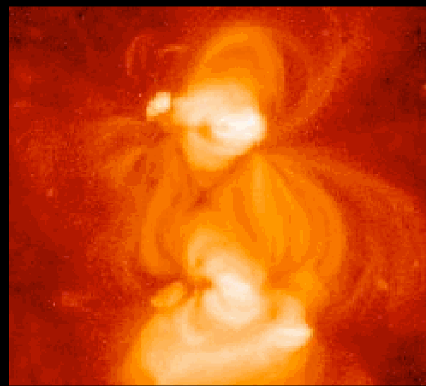
low temperature, only part of particles are ionized

T ~ several thousands K

Hot plasma (fully ionized plasma)...

high temperature, all particles are ionized

T >> 10^4 K



Examples of plasmas

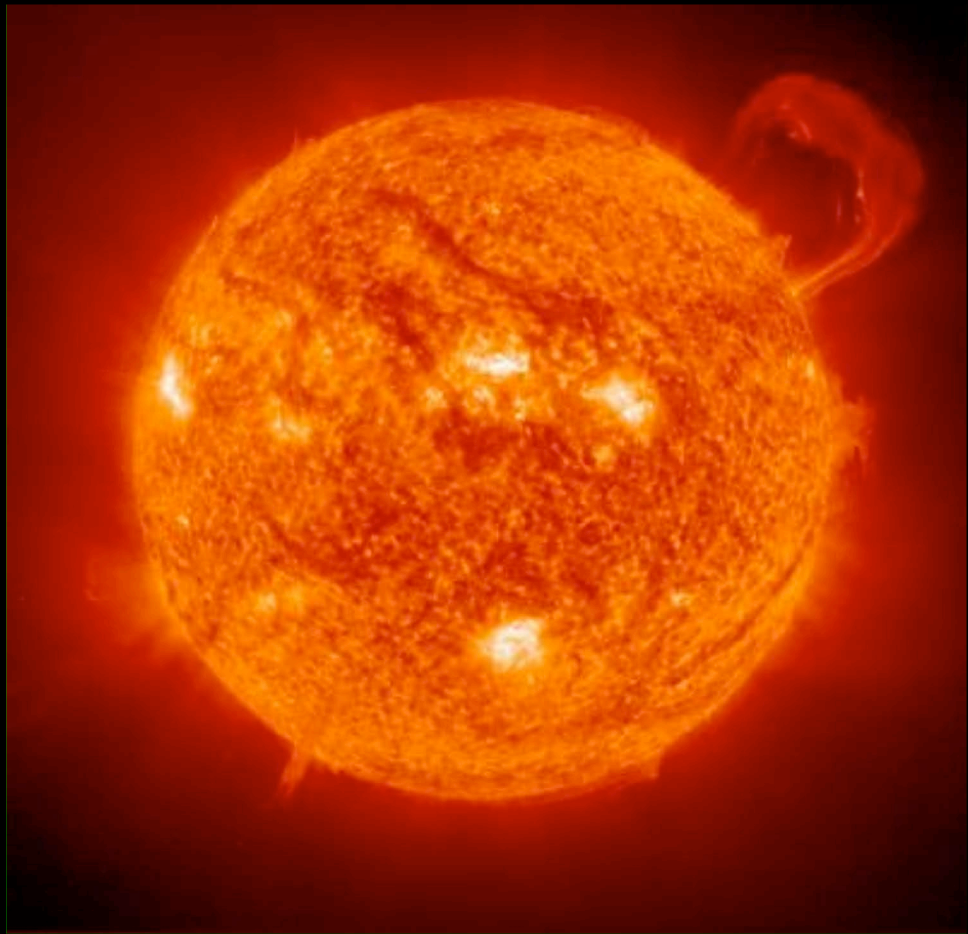
Plasmas in our daily life (cold plasma)

plasma television

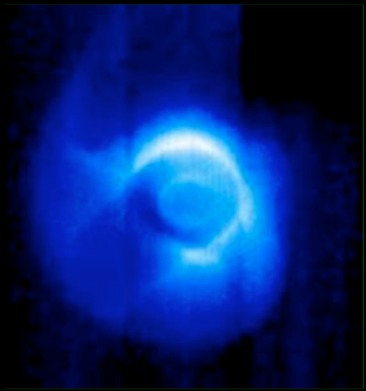
fluorescent lamp

Plasmas in the universe (hot plasma)

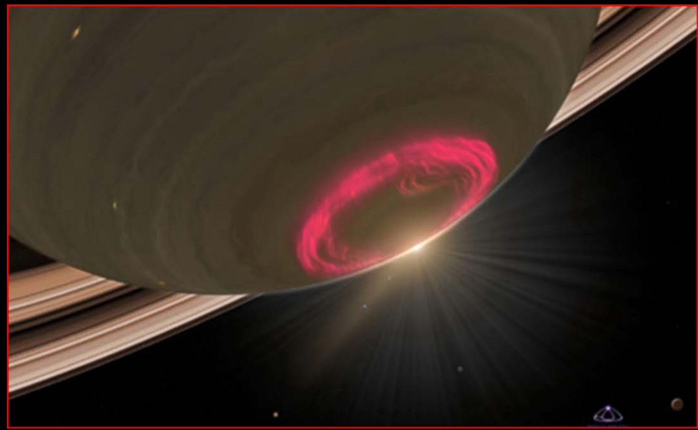
Solar atmosphere
(chromosphere)



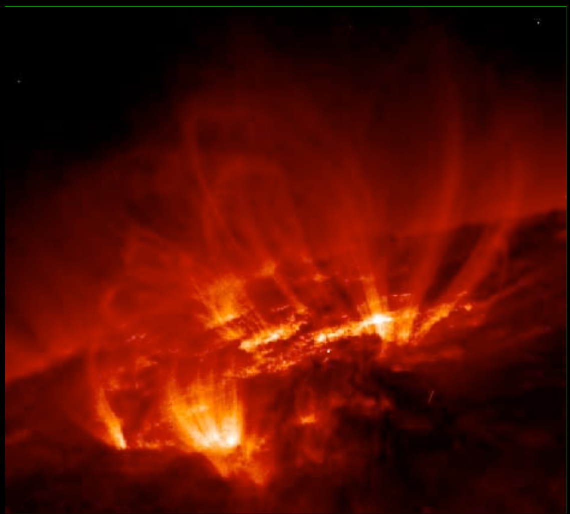
Since its temperature is very high (higher than 10,000 K), it is in a plasma state.



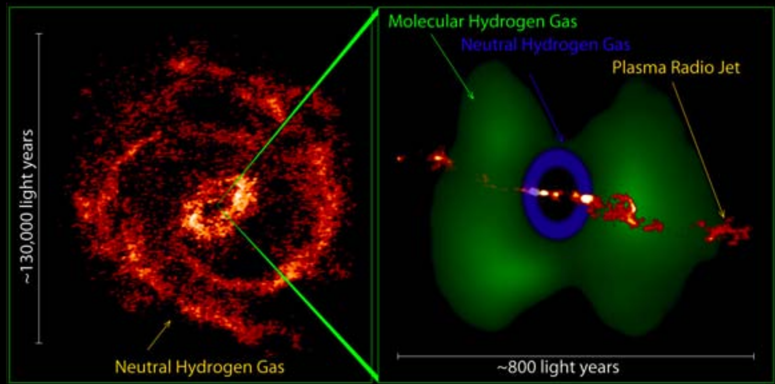
Magnetosphere



Saturn



Active region on the Sun

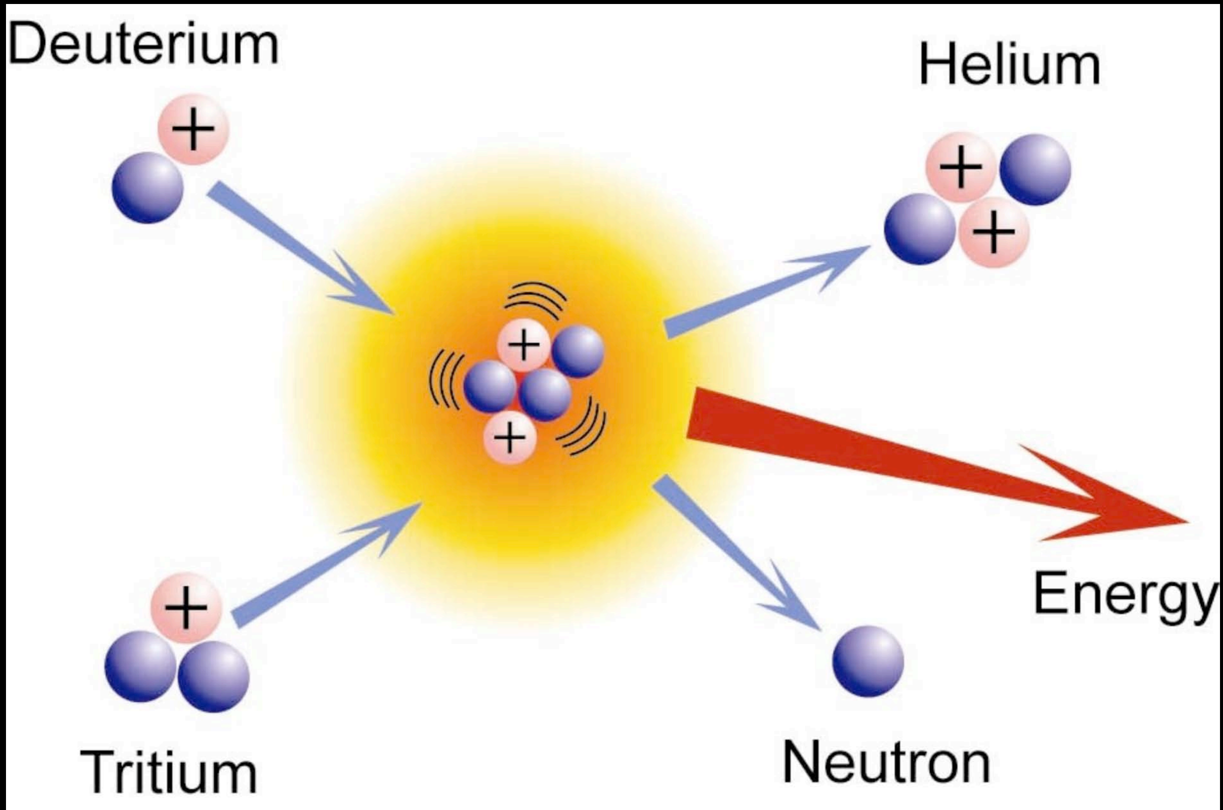


Jet in an active galactic nucleus (AGN)

Laboratory plasma (hot plasma)

Plasma in a tokamak

Plasmas... future energy resource **(via nuclear fusion)**



Temperature... 10^8 K

Density... 10^{14} cm^{-3}

↔

Surface of the Earth

T ~ 300 K,

Density ~ 10^{19} cm^{-3}

How can we confine a 100,000,000 K plasma?

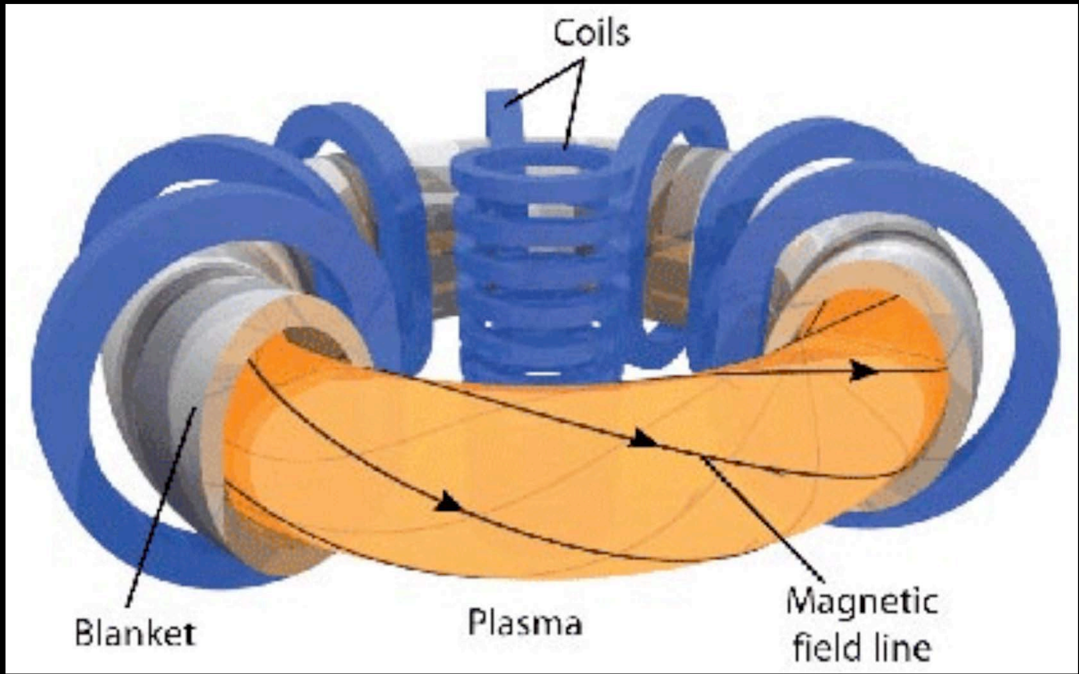
Even for the matter that has the highest melting point, this is less than 4000 K ('***tungsten***' whose melting point is about 3695 K).

This means that even if ***tungsten*** is used to try to confine a plasma, it will be melted and vaporized immediately.

Therefore, we cannot use <u>a solid body</u> to confine a plasma.

Instead, we use ***magnetic field*** to confine a plasma.

Magnetic field is used to confine a hot plasma...



Iron... melting point ~ 1808 K
Tungsten... melting point ~ 3695 K

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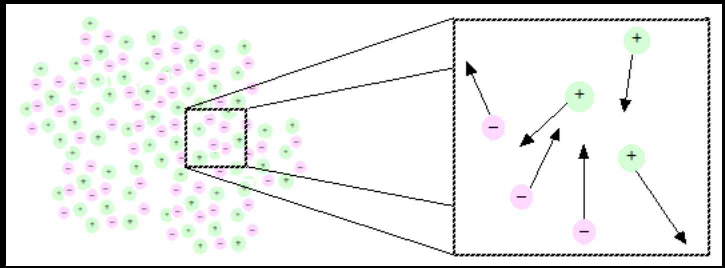
Plasma... T > 10000 K

Basic properties of plasmas

1. Local charge neutrality

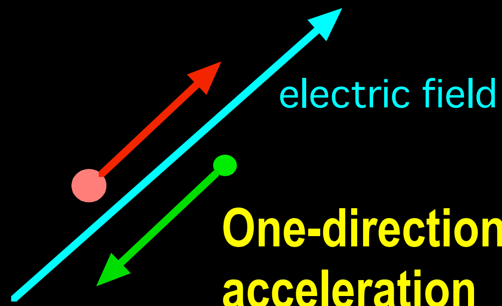


The numbers of positive charges and negative charges are almost the same in every local region.

2. Interaction with electric field (Coulomb force: $F_C = q\,E$)

Red... ion (+)

Green... electron (–)



One-directional acceleration

Charged particles are accelerated along electric field.

$$\frac{d\mathbf{v}}{dt} = \frac{q}{m}\mathbf{E}$$

Magnitude of *v* is changed.