



# *Physical Meteorology1*

## *Lecture 2*

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*Exosphere*

*Thermosphere*

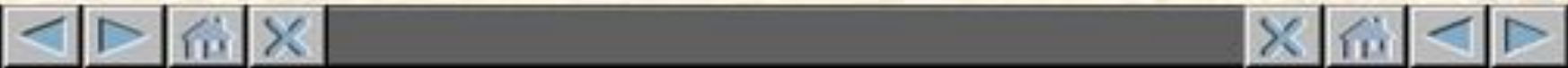
*Mesosphere*

*Stratosphere*

*Troposphere*



**Major Subdivisions of the Atmosphere**



## Definitions



***Aerosol:*** suspension of fine solid or liquid particles in a gas.

***primary aerosol:*** emitted directly as particles.

***secondary aerosol:*** formed in the atmosphere by gas-to-particle Conversion.

***fine aerosol:*** particles  $< 2.5 \mu\text{m}$

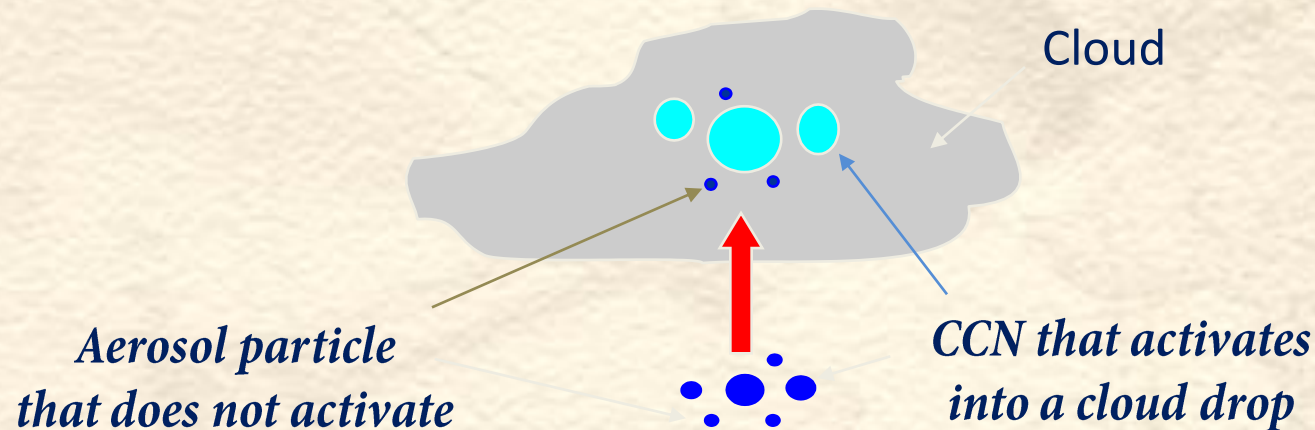
***coarse aerosol:*** particles  $> 2.5 \mu\text{m}$

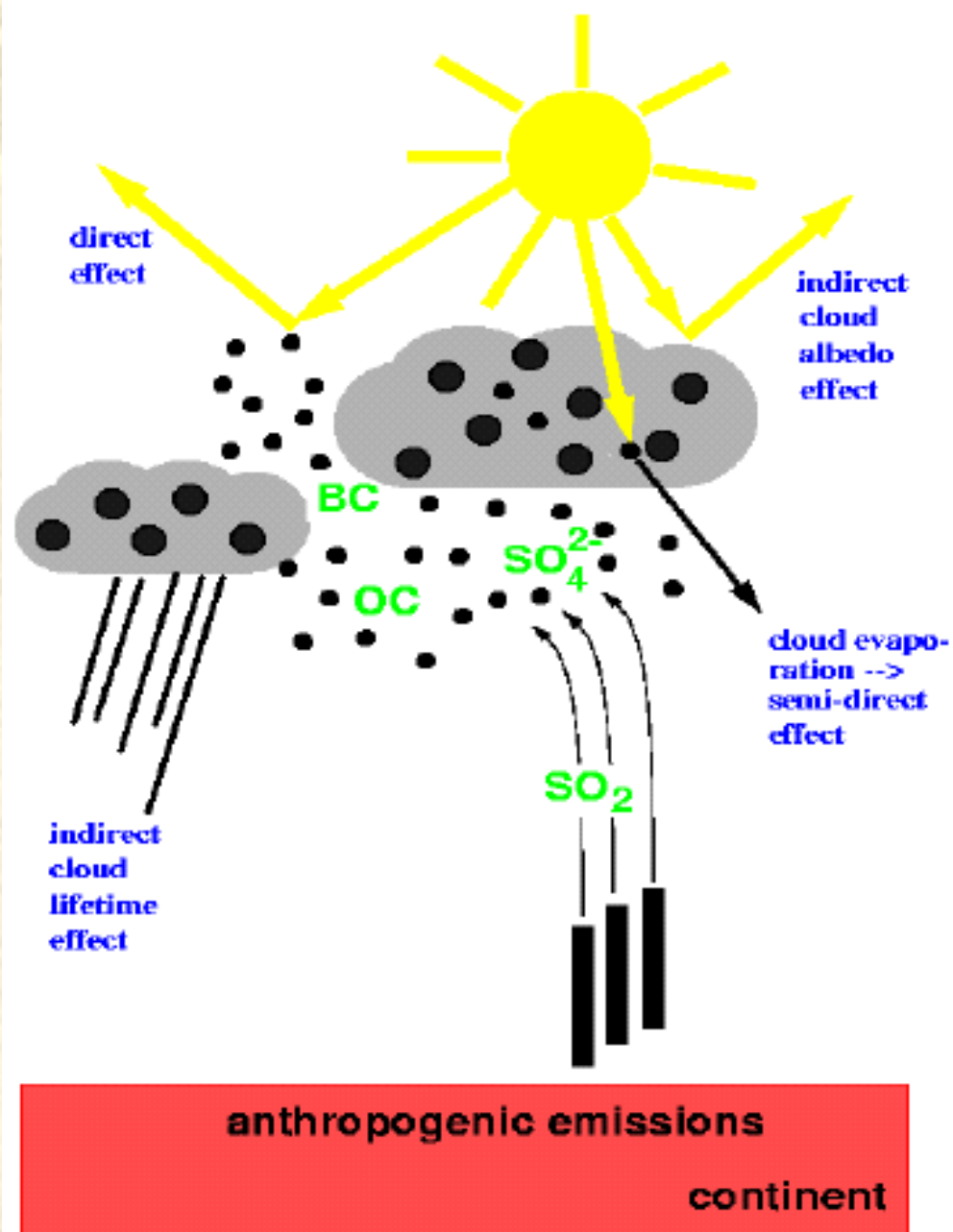
## Importance of atmospheric aerosol

اهمیت ایروسول جوئی

*Without the presence of aerosols to act as **cloud condensation nuclei (CCN)** for water droplets, could not form under normal atmospheric conditions.*

ذرات جاذب الرطوبه بعنوان مراکز و محل های تجمع قطرها عمل می کنند.





## *aerosol effects on clouds*

Clouds play a major role in the climate system  
A small change in cloud properties can strongly affect climate.



## Air pollution

*Air pollution is a problem in many of areas of the world. It can damage trees, lakes and animals, and make people sick. It can also damage buildings and other structures. Air pollution also can cause haze, reducing visibility in national parks and sometimes interfere with aviation (Perkins, 1974).*

### تعریف آلودگی هوا:

هرگونه تغییر در ویژگیهای متشکل هوا که بطور مستقیم یا غیر مستقیم منافع و حیات موجودات زنده را به مخاطره اندازد.

# Major Atmospheric Pollutants

## آلوده کننده های شاخص جوی

پنج نوع از مواد به عنوان آلوده کننده های عمده هوا شناخته شده اند که باعث بوجود آمدن بیش از 90% از عوامل آلودگی هوا می شوند.

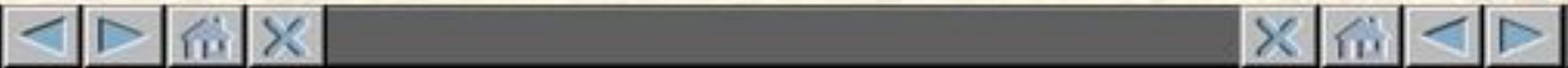
- (1) **کربن منوکسید** *Carbone Monoxide (CO)*
  - (2) **اکسیدهای سولفور** *Sulfur Oxides (SOx)*
  - (3) **ذرات معلق** *Particulate Matter (PM)*
  - (4) **هیدروکربن ها** *Hydrocarbons (HC)*
  - (5) **اکسیدهای نیتروژن** *Nitrogen Oxides (NOx)*
- ازن *Ozone (O<sub>3</sub>)*



## گازهاي كمياب (Trace gases):

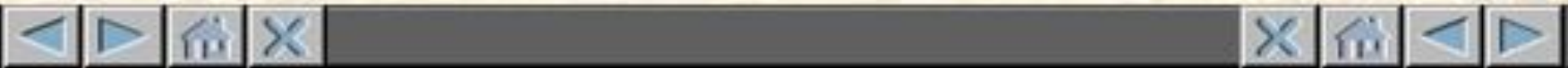
به گازهايي اطلاق مي شود كه از غلظت كمى در هوا برخوردار باشند.

*The remaining less than 1% of the atmospheric gases are known as trace gases because they are present in such small concentrations. They include carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), carbon monoxide (CO), nitrous oxide (N<sub>2</sub>O), nitrogen oxides (NO<sub>x</sub>=NO+NO<sub>2</sub>), sulphur dioxide (SO<sub>2</sub>), chlorofluorocarbons (CFCs), ammonia (NH<sub>3</sub>), hydrogen sulphide (H<sub>2</sub>S), dimethyl sulphide (DMS) (CH<sub>3</sub>SCH<sub>3</sub>) and ozone (O<sub>3</sub>).*



# Importance

*These trace gases play a crucial role in the Earth's radiative balance and in the chemical properties of the atmosphere. Despite their relative scarcity, the most important trace gases in the Earth's atmosphere are the greenhouse gases. These trace gases are important because of their ability to produce daytime and night time vapour species which can either condense to form new particles or condense onto existing particles. Furthermore, the  $\text{NO}_x$  and CO levels, (or more precisely the changes in those levels); provide a good tracer for the amount of traffic activity in a city, as they are a direct measure of primary emissions from vehicles (Williams; 1999).*



## *Weather and Air*

- *Weather:*

*State of the atmosphere at a particular place and time.*

*What's the temperature, precipitation, cloudiness, wind speed etc.*

- *Air: A mixture of gases.*

## *Weather & Climate*

*Weather is comprised of measured:*

- a) air temperature    b) air pressure*
- c) humidity            d) clouds*
- e) precipitation        f) visibility*
- g) wind*

*Climate represents long-term  
(e.g. 30 yr) averages of weather.*

## *Weather and Climate*

- *Climate is*
    - *Long-term average of atmospheric variables*
- Such as*
- *Temperature*
  - *Pressure*
  - *Wind speed and direction*
  - *Precipitation*
  - *Others*
- *And maxima, minima, extreme values, etc.*

# *Climate*

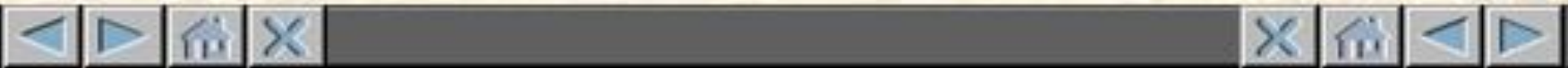
- *Human activities (normal behavior, culture, architecture, agriculture) determined by climate*
- *The conditions we expect*
- *The slowly varying aspects of the atmosphere–hydrosphere–land surface system*

# *Meteorology*

هواشناسی

*Meteorology is the study of the atmosphere and the processes that cause atmospheric motion and the development of methods for applying that knowledge to practical problems. Although this field is usually associated with weather prediction.*

*Meteorology is the study and forecasting of weather changes resulting from large scale atmospheric circulation*



## *Physical Meteorology*

## هواشناسی فیزیکی

به فرآیندهای فیزیکی که در جو پایین روی می دهد می پردازد. یعنی سیر تغییرات و تبدیلات انرژی را مطالعه می کند.

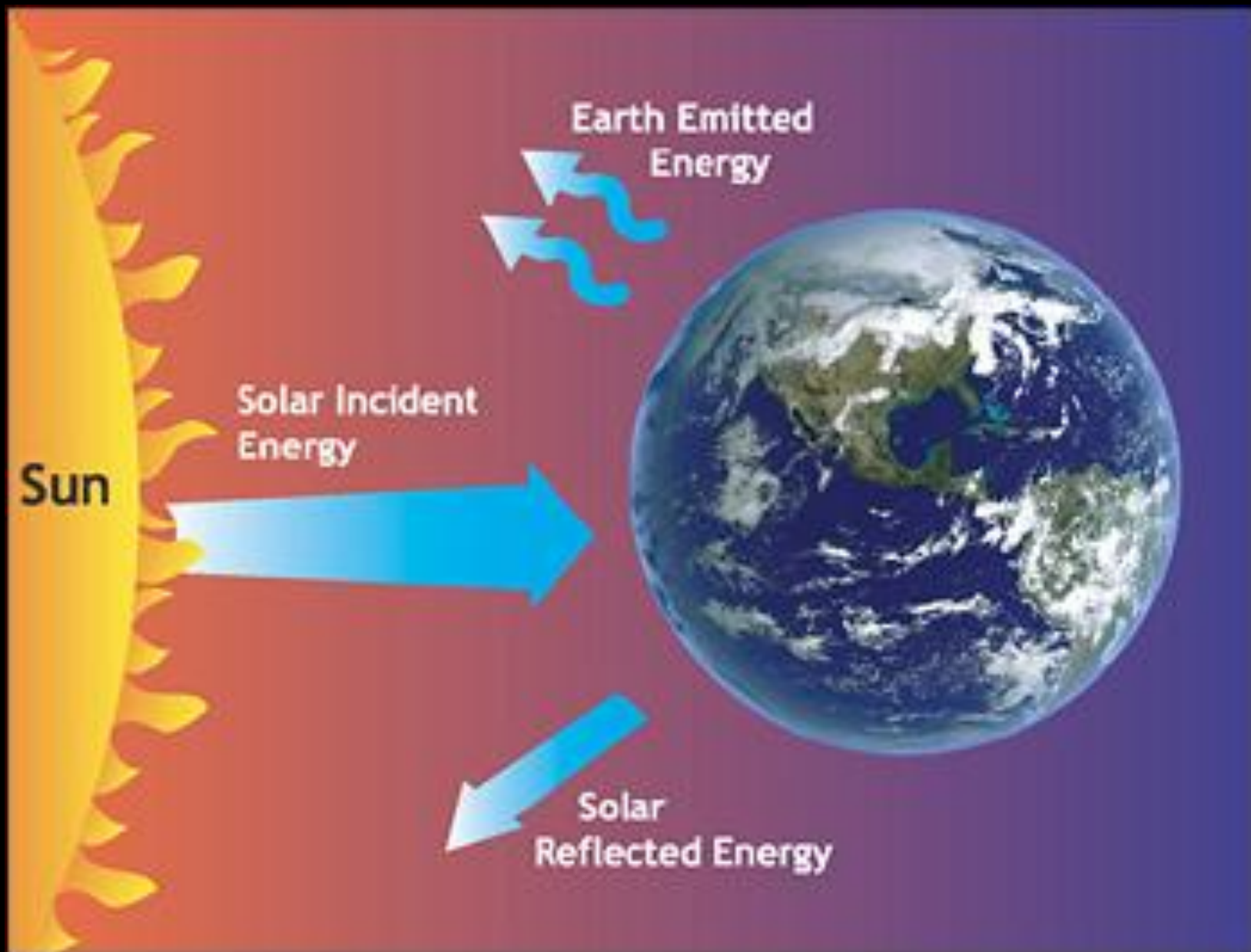
- *atmospheric electricity*
- *atmospheric optics*
- *cloud and precipitation processes*
- *the planetary boundary layer (PBL) and transfer processes*
- *solar and terrestrial radiation*
- *remote sensing (radar, satellite, etc.)*

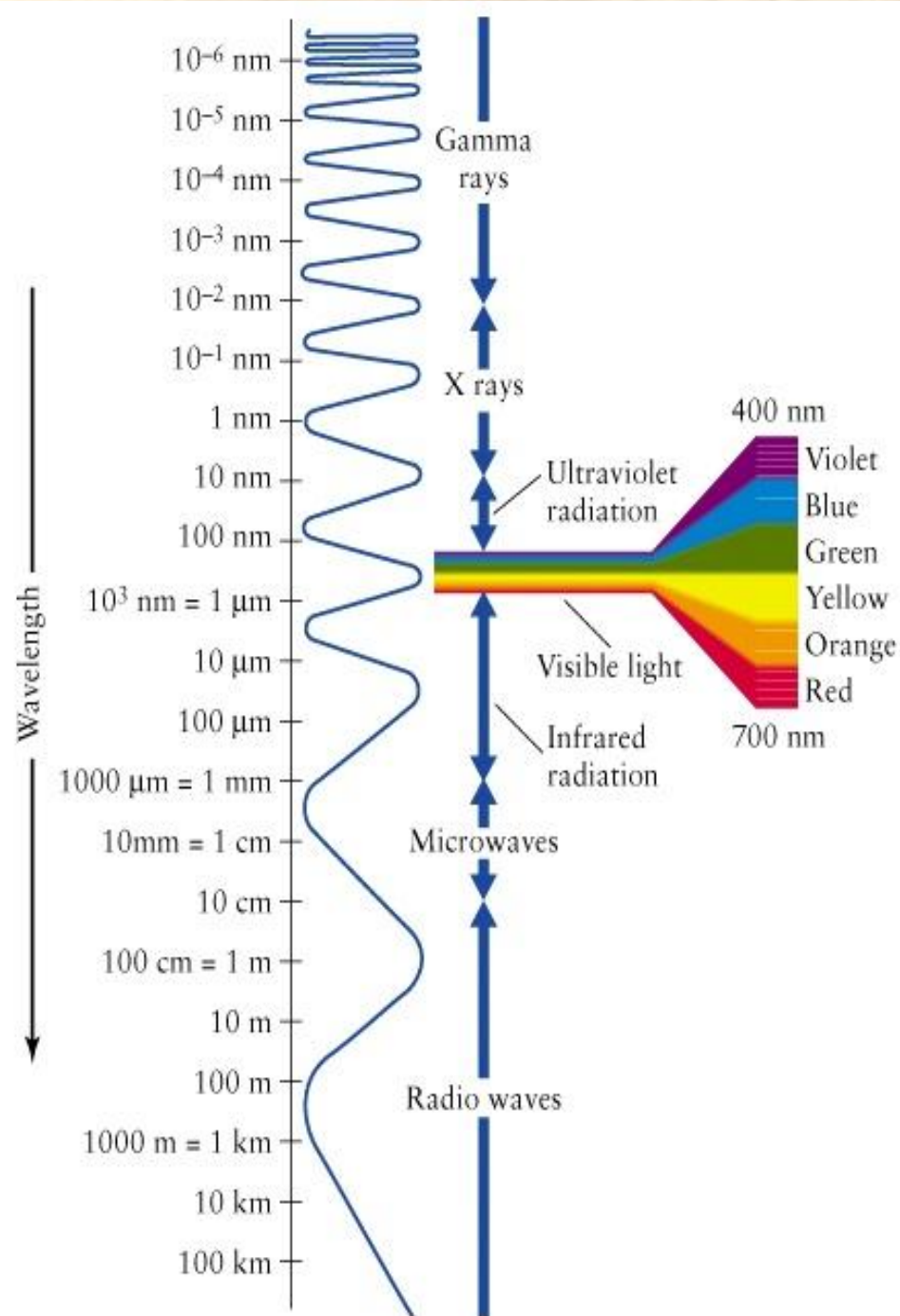




# تابش خورشیدی

خورشید سرچشمه اصلی انرژی بیشتر  
فرایندهای است که در سیاره ما روی می دهد





# Fusion of Hydrogen into Helium

## The Sun's Source of Energy

- *Nuclear Reactions: The Sun's energy comes from nuclear reactions in its core.*  
*More specifically, the energy comes from the fusion (joining) of nuclei of hydrogen atoms into nuclei of helium atoms. The actual fusion process takes place in several steps, which may be summarized as follows:*

Four hydrogen nuclei get fused into one helium nucleus, accompanied by the emission of neutrinos and release of energy:



$^1\text{H}$  = nucleus of hydrogen atom

$^4\text{He}$  = nucleus of helium atom

*Neutrinos are subatomic particles that travel close to the speed of light and only rarely interact with matter.*

# *Where Does the Energy Come from in the Fusion of Hydrogen into Helium?*

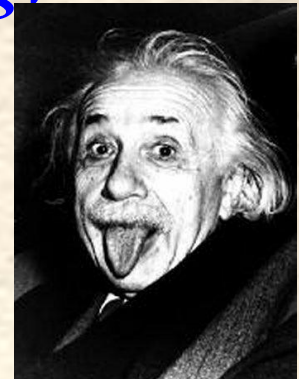
*During the fusion of hydrogen, approximately 0.7% of the mass of hydrogen is converted into energy. This means that the resulting helium has 0.7% less mass than the original hydrogen. Einstein's famous formula tells us how much energy this loss of mass generates:*

*Hydrogen + Hydrogen = Helium + energy*  
*difference in mass converted to energy*

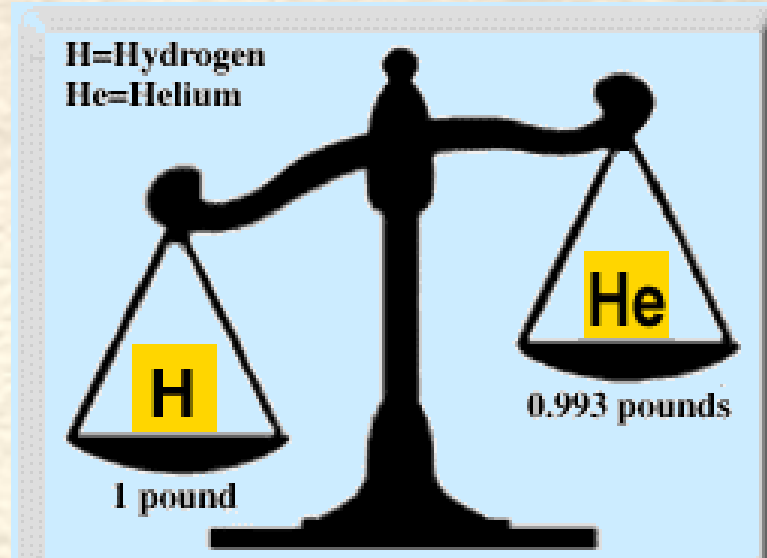
$$E=mc^2$$

famous Einstein

mass=energy



*Since the speed of light ( $c$ ) is very large and comes in squared, the amount of energy generated by the fusion of hydrogen is very large, even though the amount of mass that disappears is very small.*



*If we could weigh the helium produced by the fusion of 1 pound of hydrogen, we'd find it weighs only 0.993 pounds. The difference, namely 0.007 pounds, has been converted into energy.*

NUCLEAR "ENERGY" is the conversion of mass to energy

