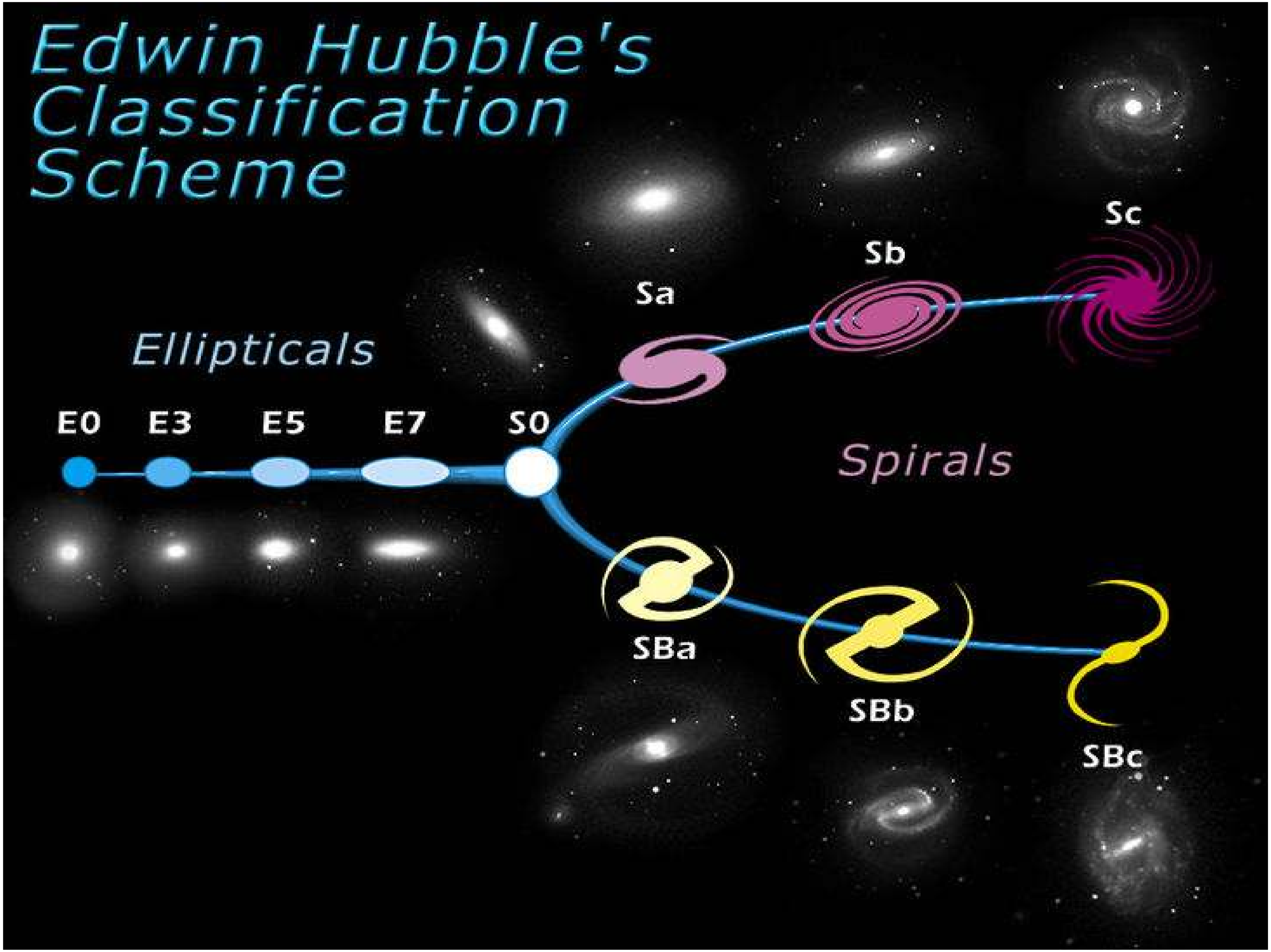

Starburst

What is starburst?

- A process by which dense part of a molecular cloud in to a boll of plasma to form star.
- A large amount of cool molecular gas in a small volume, Such concentrations and perturbations are strongly suspected to cause global starburst phenomena in major galaxy mergers,
- Observational surveys have long since shown that there is often a burst of disk star-formation in merging and interacting pairs of galaxies

Type of Galaxies

- Elliptical Galaxies: have a simple elliptical appearance , and classifies according to degree of eccentricity
- Spiral Galaxies: they are spiral in their structure and two third of the bright galaxies populations
- Lenticular Galaxies: the intermediate type between spiral and elliptical
- Spherical Galaxies: it looks like spherical

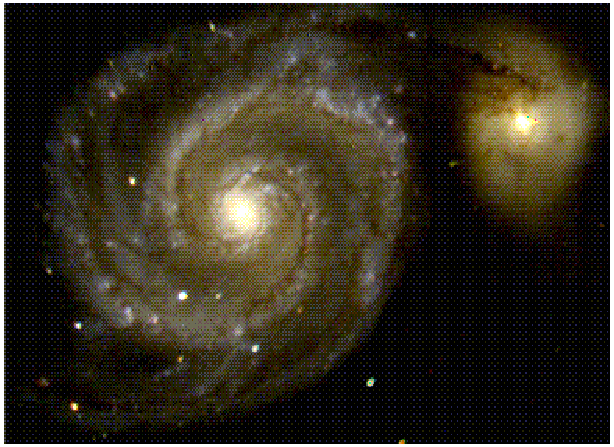


Edwin Hubble's Classification Scheme
Ellipticals
E0
E3
E5
E7
S0
Sa
Sb
Sc
Spirals
SBa
SBb
SBc

Spiral Galaxies

Its make up of two third of all bright galaxies. They are subdivided in to classes Sa,Sb and Sc

Sa



Sb

Sc

Sub spiral galaxies

There are barred spiral galaxies similar to spiral galaxies in characteristics and in classification of its sub classes, SBa, SBb and SBc

NGC
3992
SBa

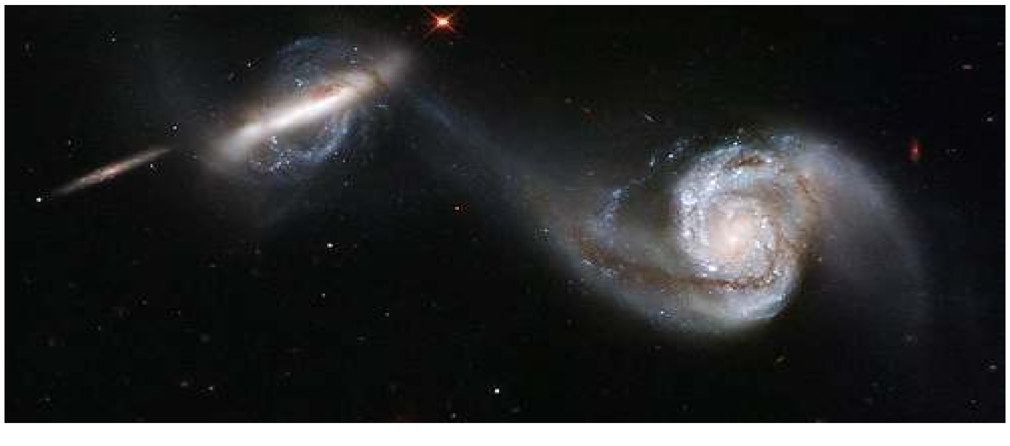
NGC
1433
SBb

NGC
1300
SBc

Interaction of galaxies

Since galaxies in a cluster are constantly in motion because of mutual gravitational force between them and with their neighbors. Those interactions come in a number of shapes and forms which depend up on number of constraints

- Constraints are mass and distance between the galaxies
- if the two galaxies have similar mass then the result of interaction are very different when one galaxy is much larger than the other
- some galaxies pass one another and simply their presence felt from a distance while other plunge together and merge in to one
- If two galaxies pass each other at close range then the tidal force between the two galaxies will produce interesting distortions . For instance bridges



Merges of Galaxies

- When galaxies collide they simply pass through each other, but the gravitational effect disturbs their structure as this happens
- If they are gravitational bound bring them back together for another collision.
- After several collision their individual structure so changed, with many star mixed up between them, that we identified a single merged object

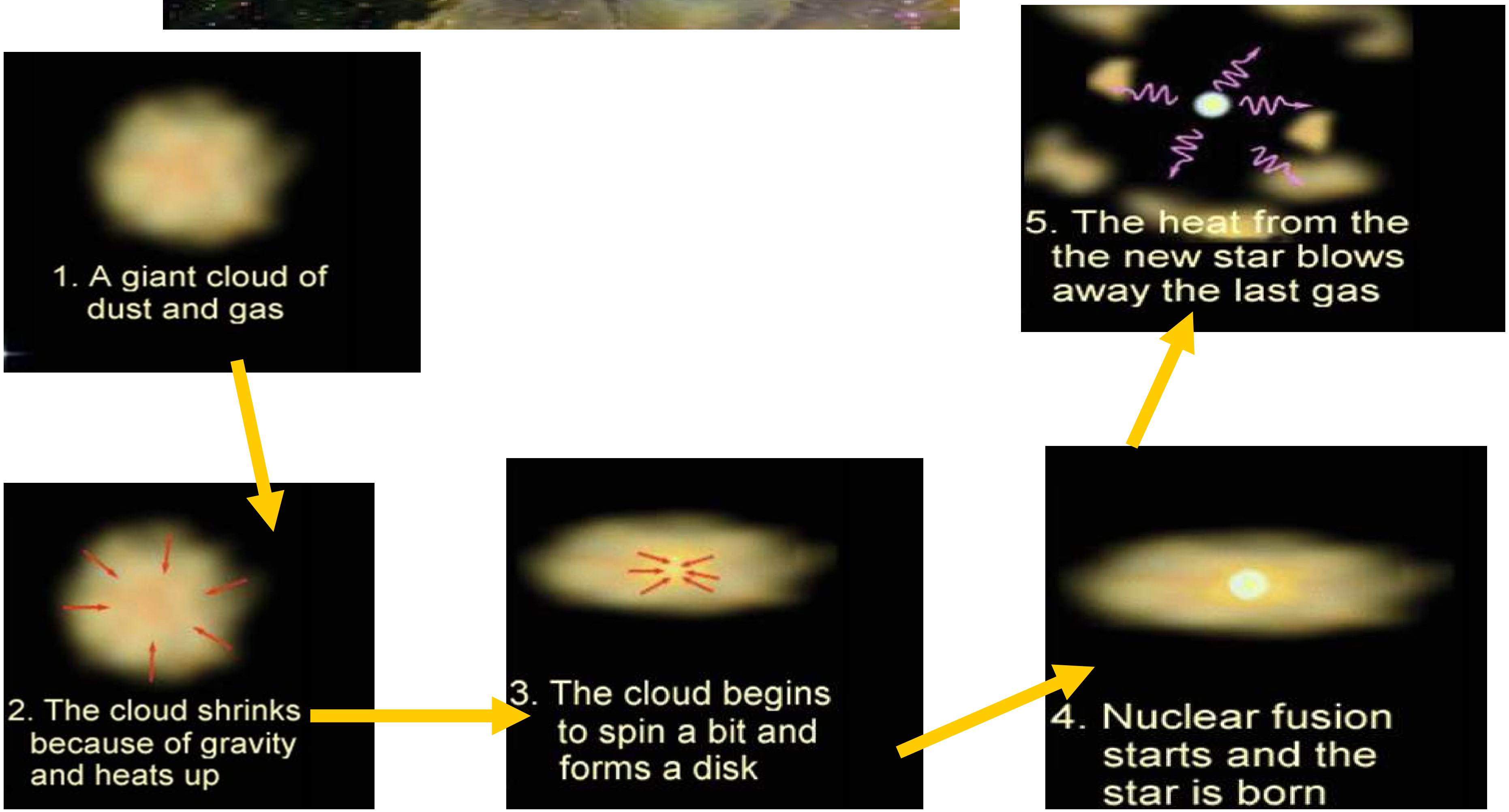
Molecular cloud

- A molecular cloud is constitute the densest part of the interstellar medium in galaxies and provide useful information on galaxies evolutions and structure
- Molecular cloud collapse to form stars and their presence is an important signature of the star forming potential of a galaxy
- Since the interstellar matter also serve as a waste-damp for processed material, its elemental abundance will reveal the nature of the past stellar generations
- Its dissipative component in the galaxy dynamics, it can thus significantly speed the merging process of some galaxy encounters.
- The main component of molecular cloud is Hydrogen. Although they also contain other molecular and atomic species, e.g He HI, CO

How are stars Birth?

- Stars are made (or “born”) in giant clouds of dust and gas.
- Sometimes part of the cloud shrinks (collapse) because of *gravity*.
- As it shrinks it becomes *hotter* and when it is hot enough, *nuclear reactions* can start in the centre…..
- … and A Star is Born!


The Birth
of a
Star


1. A giant cloud of
dust and gas
2. The cloud shrinks
because of gravity
and heats up
3. The cloud begins
to spin a bit and
forms a disk
4. Nuclear fusion
starts and the
star is born
5. The heat from the
the new star blows
away the last gas

How this collapses happen?

By assuming the rotational and magnetic field are ignored and the collapses of gas cloud is modelling as spherically symmetric, then the equation of motion of shell of radius r (m,t)

$$\frac{\partial^2 r}{\partial t^2} = -\frac{Gm(r)}{r^2} - \frac{1}{\rho}\frac{\partial P}{\partial r} = -\frac{Gm(r)}{r^2} - 4\pi r^2 \frac{\partial P}{\partial m(r)}$$

The cloud will be in equilibrium if the two terms on the right hand side balance each other; it will expand because of the pressure if the second term dominates in characteristics time scale.

$$t_{cool} \approx R/c_s \propto (m/\rho)^{1/3} T^{-1/2} \propto (m)^{1/3} (\rho)^{-1/3} (T)^{-1/2}$$

Where $c_s \approx (P/\rho)^{1/2}$ is a speed of sound in the gas.

It will collapse under self gravity if the first term dominates on the right hand side in a time scale.

$$t_{grav} \approx \left(\frac{Gm}{r^3} \right)^{-1/2} \propto (G\rho)^{-1/2}$$

This consideration suggests that cloud with large densities (which implies large m) will have $t_{grav} \ll t_{cool}$ and will be unstable for collapsing under self gravity. The same can be obtain in different manner along the following manner

How This Collapse Happen using Virial theorem ?

- Virial theorem states that: the average over time of total kinetic energy $\langle T \rangle$ of a stable system bounded by a potential force with that of total potential energy $\langle V_{\mathrm{TOT}} \rangle$

$$2\langle T \rangle = -\sum_{k=1}^{N} \langle F_k . r_k \rangle$$

The gravitational potential energy of a cloud of mass M and radius R is

$$U = -\left(\frac{3}{5}\right)\left(\frac{GM^2}{R}\right)$$

The thermal kinetic energy is

$$\left(\frac{3}{2}\right)(NK_BT)$$ Where $N=(M/\mu m_H)$ and μ is the mean molecular weight

A cloud is unstable to collapse if the magnitude of the gravitational potential energy is larger than (approximately) twice the kinetic energy.
This gives the condition for collapse as

$$\frac{3MK_BT}{\mu m_H} < \frac{3}{5}\frac{GM^2}{R}$$

Eliminating the radius of the cloud in terms of the mean density $\rho_o = 3M/4\pi R^3$, we can express the criterion $M > M_J$, where

$$M_J \approx \left(\frac{5K_B T}{G\mu m_H} \right)^{3/2} \left(\frac{3}{4\pi\rho_o} \right)^{1/2}$$

This quantity M_J is called the Jeans mass

When such large cloud start collapsing under self gravity, its physical parameter change during the course of collapse, thereby changing the Jeans mass

If the Jeans mass decrease as the cloud collapse, then the sub regions inside the original cloud can become locally unstable and start collapsing themselves

as long as the Jeans mass going continue to decrease will continue undergoing in gravitational collapse

The Jeans mass in relation above depend on the temperature and density as

$$M_J \propto T^{3/2} \rho^{-1/2}$$

For collapsing cloud, ρ keeps increasing; whether M_J increasing or decreasing will depend crucially on the evolution of the temperature T.

As the cloud collapse, it release gravitational potential energy that can either

•Increase internal energy of the material and causes pressure readjustment

• Be radiated a way if the time scale for cooling t_{cool} is shorter than t_{grav} . If the cloud manages to radiate away the gravitational energy that is released, then it can contract isothermally

Proto Star

- cloud will continue to collapse as long as the gravitational binding energy can be eliminated
- However, the collapsing cloud will eventually become opaque to its own radiation and the energy must be removed through some other means
- The dust within the cloud becomes heated and It continues to increase in temperature as determined by the virial theorem
- The gas falling toward this opaque region creates shock waves that further heat the core, when the core temperature reach about 2000K, the thermal energy dissociates the H_2 molecules.

Watching stars being born

The Bubble Nebula

Here you can see the old dust and gas being blown away by the heat of the new star.

What happens next?

- Once nuclear fusion is producing heat in the centre of the new star, this heats stops the rest of the star collapsing.
- The star then stays almost exactly the same for a long time (about 10 billion years for a star like the Sun).
- The balance between *gravity* trying to make the star shrink and *heat* holding it up is called **Thermodynamic Equilibrium**.


Thank You