Particle creation by black hole

Quantum mechanical effect cause by black hole to create and emit particles as if there were hot bodies with temperature

$\frac{\hbar k}{2 \pi K} \approx 10^{-6} \frac{M_\odot}{M}\degree K$.

- k is surface gravity of the black hole.
- $\hbar$ is reduced planck constant.
- M is mass of black hole.
- $M_\odot$ is solar mass.

hot big bang

In1940's, Russian Physicist George Gamow conceived the hot big bang based on the observation that gas expand when cold and compress when hot.**The temperature of the gas is a measure of the average kinetic energy of it's constituent particles**. The faster the particle move the higher the temperature. Those particle collide with objects that are not stationary and it lose it's kinetic energy and thus made decrease in temperature. As much the universe expand the particle gets cooler. The temperature in the early universe is inversely proportional to the scalar factor of the universe $T \propto \frac{1}{a}$. The scalar factor **a** is a dimensional quantity describe the how much the size of the universe changes with time. The universe is infinitely hot at the big-bang as scalar factor is zero.
The universe is mainly made-up of anti-matters and matters. Our surrounding is filled with molecules which are different composition of atoms held together by chemical bond. The chemical bond which hold atoms in molecules breaks at about 500K ($1 \degree K = -272.15 \degree C$), the atom breaks into nuclei and electron around 3000K and those nuclei broke into proton and neutron with approximate of $10^8 K$. As high it goes the neutron and the proton turn to elementary particle called **quarks** at above $10^{12} K$. The earlier our solar system was a hot dense mixture of subatomic particle called "the primeval fireball".

Thermal Radiation

At microscopic level the electromagnetic waves consist of photons and their energy is inversely proportional to their wavelength $E=h \frac{c}{\lambda}$. The photons can be emitted and absorbed by electrically charged particles [in classical world photons not affected by electric field but in quantum world it interact with electrically charged particles]. In early the universe emit and absorb photons with same rate and equilibrium is formed where photons are mixed with another particles. At the macroscopic view the gas photons are referred electromagnetic radiation waves with different wavelengths. Electromagnetic radiation is in equilibrium with matter at some temperature is called thermal radiation. The total intensity is directly proportional to the 4th power of the temperature, $\rho \propto T^4 $. The spread of intensity over a ranges of wavelength is called thermal spectrum (German physicist Max Planck). The peak intensity occurs at a wavelength inversely proportional to the temperature. $\lambda_{peak} \propto 1/T$. The macroscopic object at non-zero temperature emits radiation depends on how it absorb and reflect electromagnetic radiation.

Big bang model

The big-bang model deals with the expanding fireball of elementary particles and photon. When the universe expands, the fireball dilutes, cools down and complex structure forms. After a minute of expanding the temperature decrease to 10^9K and proton and neutrons combine to form a nuclei. This process is called nucleosynthesis. [in chap:13] As 3,80,000 years passed the temperature cools to 3000K and electron combine with nuclei forms neutral atom called recombination. The star, galaxies and galaxy cluster pulled together by gravity.

Primeval fireball

Predicted first by George Gamow's colleagues Ralph Alpher and Robert Herman in 1940's which will be of 5K. After a decade and some at Bell Telephone Laboratories in New Jersey, Arno Penzias and Robert Wilson were testing a sensitive radio antenna that they hoped to use in a study of radio emission from the Milky Way. But the signal were always filled with noise. They examine everything but no clue for noise is found. When they measured the temperature of the noise which is 3K corresponding to microwave of wavelength 2mm and this is of cosmic radiation left over from big-bang. This noise was now called **Cosmic Microwave Background** (CMB).

our system

Galaxies come in three main types: spiral, elliptical and irregular. The disk of our Milky Way galaxy is roughly 100,000 light years across and about 10,000 light years thick. The halo is nearly spherical, with a diameter about ten times larger than that of the disk. The Sun sits in the disk and is located about 25,000 light years from the galactic center. Galaxies group together to form clusters. The Milky Way belongs to a small cluster called the Local Group (see Fig. 12.2). The Andromeda galaxy also resides in the Local Group, some 2.5 million light years away. the Local Group has less than 40 galaxies.

Big Bang Nucleosynthesis

About 75% of atomic matter in our universe is hydrogen and rest almost is helium and only 2% among them is others. The first step in nucleosynthesis is for a neutron to fuse with a proton to make deuterium, or heavy hydrogen. Then two deuterium combine to form either helium-3 plus a neutron, or tritium plus a proton. After 1minute of ABB (after big-bang) temperature dropped to one billion Kelvin, and the photon energies are not able break deuterium.The rate of nucleosynthesis increased rapidly. The amount of dark matter in the universe is five times about that in stars and gas. The big-bang nucleosynthesis does not progress much beyond helium that there are no stable nuclei consisting of 5 nucleons.

Stellar Nucleosynthesis

The stars are gaseous body hold together by gravity and heated by nuclear reaction in the interiors. Our Sun is a typical middle-size star, consisting mostly of hydrogen (71%). Its surface temperature is 6000 K and the central temperature is 10 7 K. Hydrogen is burned into helium in the central part and helium ash is collected at the core. As sun reaches $T \sim 10^8K$, the helium ash starts burning to carbon and oxygen and the nuclear reaction do not go beyond this. As more heat generated it turns to red giant and blow off. When the critical amount of matter is added, it undergoes supernova explosion.

Planet formation

A large, slowly rotating cloud of gas begins to contract due to gravitational forces. The gravity and rotation force causes the cloud to flatten into a thin disc. During contraction the material become denser and hotter towards center and some of the materials in the disk coalesces into a series of planets. Our Solar System consists of the Sun, eight planets, an asteroid belt between Mars and Jupiter, and the Kuiper belt beyond Neptune's orbit. The first four planets (Mercury, Venus, Earth and Mars) are called terrestrial planets as they have the same rocky makeup as the Earth; the next four planets (Jupiter, Saturn, Uranus, and Neptune) are the gaseous planets. Jupiter's gravitational bullying prevented the material in the asteroid belt from becoming a planet, and thus Saturn has more satellite than Jupiter. The material in the Kuiper belt probably never collided frequently enough to coalesce into a planet.