Application in Astrophysics :-

The Doppler effect has a number of applications in astrophysics. Some of them are;

1.) Velocity of stars :

If a star moves either towards or away from an observer on the earth, its spectral lines shift either towards the blue or towards the red end of the spectrum. This phenomenon can be used to estimate the velocity of the star. For this a photograph of the spectrum of the star is taken. The spectral lines are then compared with the same lines obtained by photographing the spectrum of an element in the laboratory. If the former are displaced towards the red known as redshift. The star is

receding from the earth and if it is displaced towards the blue (or violet). the star is approaching the earth.

2) Rotation of the Sun :-

The Sun is rotating about its own axis. If the eastern and western edges of the Sun's disc are viewed. it is found that one edge is moving towards the earth and the other is moving away from the earth. Each edge contains absorption lines due to elements such as iron vaporised in the Sun and also some absorption lines due to the presence of oxygen in the earth's atmosphere. Therefore, if spectral photographs are taken of the east and west edges of the Sun and the two photographs are put together so that the oxygen lines coincide. Then the iron lines in the two photographs are found displaced ~~opposit~~ opposite to each other. By measuring this displacement the velocity of rotation of the Sun can be found. Measurements show a rotational speed of Sun of about 2 Km/Sec.

3) Spectroscopic Binaries :-

Examination of the light from certain stars show a periodic doubling of spectral lines. This indicates that each such star is, infact a double star revolving about one another.

Therefore, while one is approaching the earth, the other is going away. These stars are called Spectroscopic binaries.

4) Nabulae:

The spectral lines from certain distant nabulae appear to shift towards the red end of the spectrum. A measurement of this shift gives information about the velocities of nabulae relative to solar system.

5) Saturn's Rings:

The Planet Saturn is surrounded by concentric rings. The nature of these rings can be established by examining the sun light reflected by them. If the rings were solid then the velocity of the outer edge would be greater than that of the inner one. Hence, the light from outer edge would show a greater Doppler shift of the Fraunhofer lines than that from the inner edge.

If on the other hand the rings consisted of tiny particles (satellites) moving round the Saturn the particles nearer to Saturn must have greater velocity than those farther away. Because by the principle of satellite, if a satellite of mass m be moving round a planet of mass M with a velocity v in an orbit of radius R, then

Centripetal force = Gravitation al force i.e.

$$\frac{mv^2}{R} = \frac{GmM}{R^2}$$

or $$v^2 = \frac{GM}{R}$$

$$\therefore \quad v \propto \frac{1}{\sqrt{R}}$$

This shows that as R decreases v increases.

Hence the light from the inner particles should show a greater shift. This is actually found to be the case, thus establishing that the rings are made up of swarms of particles.