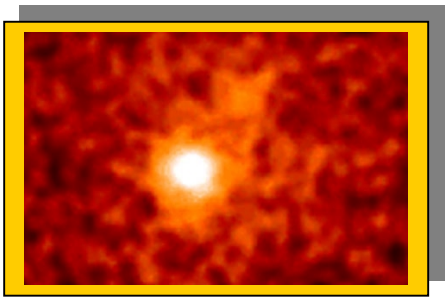
Cosmic Chemistry: Cosmogony

Doppler Effect—Are You Coming or Going?

STUDENT REPORTING/DATA SHEET

Name/Team_____



NASA

The bright image above is quasar 3C279. Quasar 3C273 is faintly visible above and to the right of center.

PART 1

Calculation of frequency of marbles rolling down track

a) Stationary "receiver"
Time _____; Number of marbles _____; Frequency _____

b) "Receiver" moving toward the "source"
Time _____; Number of marbles _____; Frequency _____

c) "Receiver" moving away from the "source"
Time _____; Number of marbles _____; Frequency _____

PART 3

a). Refer to the student handout, Figure 1. Spectrum A represents a possible spectrum of a star not moving toward or away from Earth. Spectra B and C show what would happen if the same star were moving with respect to the Earth. Compare the three spectra and answer the following questions:
   i. Which spectrum is that of a star moving toward Earth? _____
   ii. Which spectrum is that of a star moving away from Earth? _____
   iii. Explain your answers using the terms blue shift and red shift.

b) Refer to the student handout, Figure 2. This is the spectrum of quasar 3C 273 showing four visible spectral lines of hydrogen. The arrows show how the lines are shifted by the motion of the quasar relative to Earth. Is the quasar moving toward or away from Earth? Explain your answer in terms of red or blue shifts.

c) Refer to the Spectral Data Sheet, Figure 3. This series of emission lines have been observed in galaxies having varying distances from Earth. The spectra have been redrawn from actual spectra of hydrogen measured in a laboratory to enhance their clarity. What conclusions about the motion of distant galaxies might be drawn from these observed astronomical spectra?

d) Assume that there is a distant galaxy speeding away from Earth at a speed of 3500 km/sec. If a hydrogen atom in this galaxy emits electromagnetic radiation having a wavelength of 21 cm, what wavelength will the radiation have when it is received on Earth?

Question: Would the radiation be blue or red shifted?

Calculation of wavelength:

e) Assume that in a distant galaxy an atom emits green light having a wavelength of 500 nm (nanometer abbreviated – 10^{-9} meter) and assume that this galaxy is moving relative to Earth. Determine the minimum velocity with which the galaxy would have to be moving for the green light to be shifted out of the range of human vision. The human eye can detect light/radiation with a wavelength of 400-800 nm.

Question: In which case would the velocity have to be greater for the light to be shifted out of the range of human vision: if the galaxy is moving toward Earth or away from Earth?

Calculation of velocity:

f) Refer again to Figure 2 on the Spectral Data sheet and estimate the speed of quasar 3C 273 relative to Earth.