Furthest Ever Galaxy Discovered

When the Universe was Young

Biman Nath

It is not surprising to hear the astronomers recently finding a galaxy much farther than all known galaxies. What was surprising is that the most distant object known to us now is not a peculiar, enormously bright quasar, but a run-of-the-mill galaxy. As one looks at larger distances, the chances are that one would miss the normal galaxies, and mostly detect only the brighter (which happen to be peculiar) galaxies. That one found a relatively faint galaxy at such a distance has come as a pleasant surprise.

Distances are tricky in cosmology because space is curved in the universe. And the exact geometry of the universe is not yet known (although there are some clues). What is directly measured, however, is the redshift of photons. As the universe expands, the wavelength of a photon also gets stretched, and the colour gets shifted towards red. The 'redshift' tells us by how much the universe has expanded since the light that one sees now was emitted. For example, when you detect a photon which is emitted at λ_e, and you observe it having a wavelength of λ_o, the factor by which the wavelength has increased is defined as $1+z= \lambda_o/\lambda_e$, and z is called the redshift of the photon.

It turns out that space expands by the same factor. In other words, when the light that you observe with a redshift of z was emitted not only the wavelength of the photon, but the universe was also $1+z$ times smaller in size. The age of the universe corresponding to this redshift z can be determined if one assumes a geometry of the universe. For a popular model of the universe (for the curious reader, the universe which is neither closed nor open), redshift of 2, for example, would correspond to an age of the universe that is 20% of its age now. (The exact age does not depend only on the geometry, but also on some other parameters, which are still uncertain. But cosmologists believe that our universe is roughly 10–15 billion years old.)

What the group of American astronomers (from Berkeley and Johns Hopkins University) have found is a galaxy at a redshift of $z=5.34$. This redshift puts the object in an era when the universe was barely about 7% of its age now (for a 30 year old person, it would correspond to an age of only 2 years). They found it while looking for red objects in the sky. New born galaxies, which shine mostly in the ultraviolet, because of the young stars (which are blue), would look redder when seen from such a distance, because of the reddening of light from the expansion of the universe. So, they took photographs of a patch of the sky in ultraviolet, blue and red filters, and looked for objects which looked very red (brighter in red filtered photographs than in ultraviolet or blue). And then they obtained its spectrum, which showed the characteristic line emission from hydrogen atom (1st excited level to the ground level)– the Lyman α line. The rest wavelength of this line is 1216 Å and they saw it redshifted by a factor 5.34. (They detected only one line in the spectrum; although how they diagnosed this line to be the redshifted version of the Lyman α line is less straightforward, they had a few compelling astrophysical reasons to do so.)

Once the redshift was measured, one could then calculate (after assuming a simple geometry of the universe) the intrinsic brightness of the object. It turned out to be less luminous than our Galaxy, the Milky Way, and much like that of our satellite galaxy, the Large Magellanic Cloud. This came as a surprise. Earlier, astronomers had to console themselves with finding bright, peculiar galaxies, like quasars (with a brightness thousand times that of the Milky Way) at such distances. The most distant (that is, object with the highest redshift) known earlier was a quasar at $z = 4.9$. It was only after pushing the present-day technology of detectors to the edge that one could find a not-so-bright galaxy from the young universe.

This is good news because astronomers can now study the evolution of a normal galaxy, instead of the giants among them (the quasars). Finding out how a small galaxy looked like when the universe was so young can shed light on how galaxies might have evolved. Already this particular galaxy seems to say a number of interesting things. For example, from the shape of the Lyman-α line (how the intensity varies with frequency), it seems that gas in the galaxy must have had large outward motion. Recently this signature has also been seen in a few galaxies at redshifts of around $z = 3$. This is probably because of the outward push from gaseous wind from young stars and explosions from dying stars.

How common was this phenomenon in the early universe? How fast did the stars form then compared to the rate seen in the present-day universe? Did galaxies grow as single objects, or merge with others to form bigger galaxies, as the cosmologists believe? These are some of the questions that astronomers hope to answer from the study of these distant objects from long ago.

NOTE: Just before this story went to press, another group of astronomers (from University of Hawaii) reported a galaxy (again a normal one) from $z = 5.64$, at a larger distance than the earlier one. This was also detected in the process of looking for very red objects. The hunt for galaxies from an even younger universe is on.

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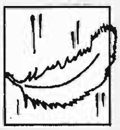

Men love to wonder, and that is the seed of science.

Emerson