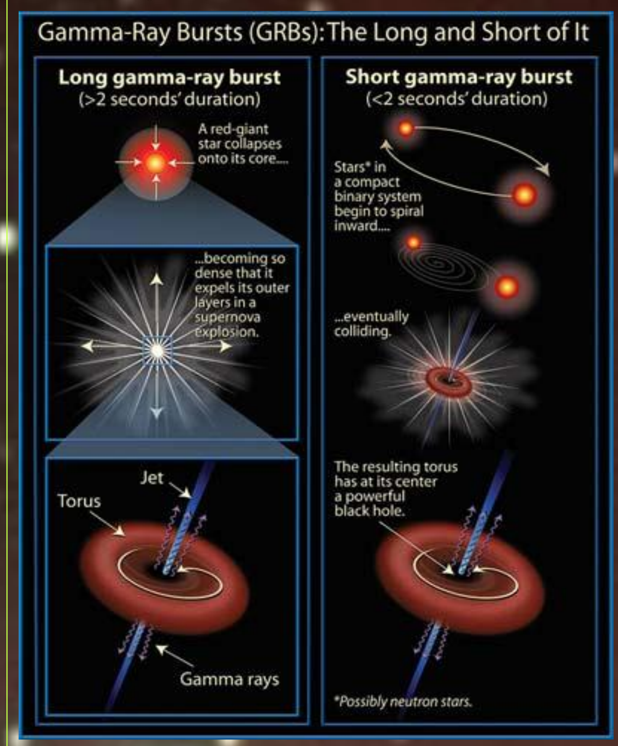
STARS

WORK DONE @ IUCAA

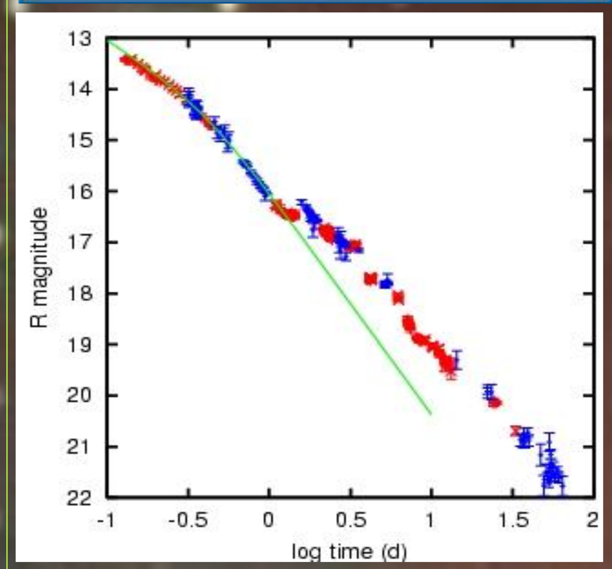
Exploding Stars: Supernovae and Gamma Ray Bursts



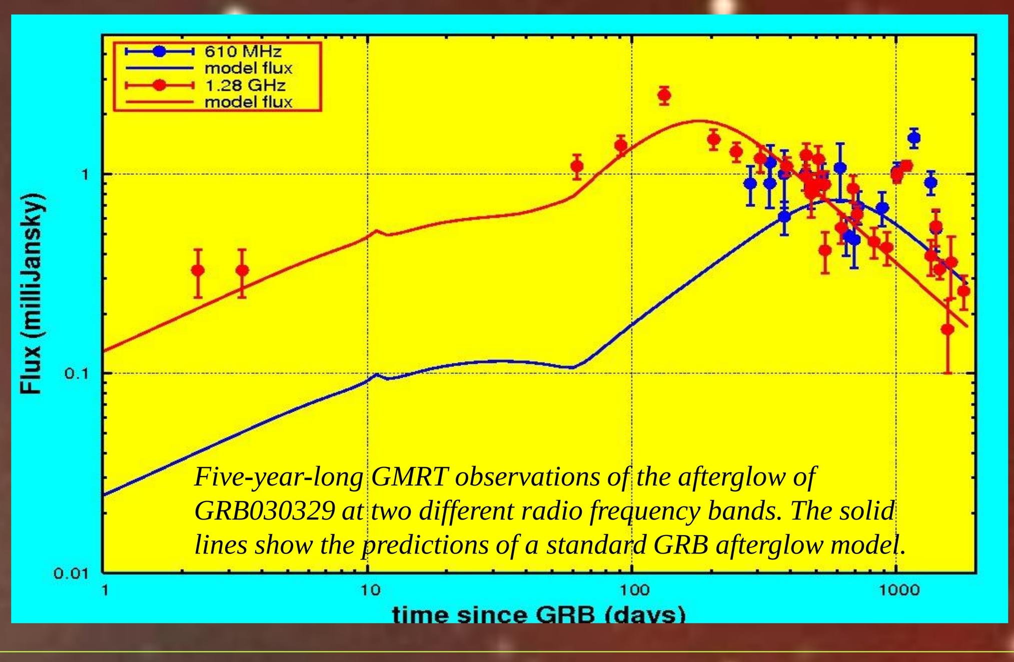
In the end phase of a massive star an enormous amount of gravitational binding energy, ~10^{53} erg, is suddenly released due to collapse of the core, an event called Supernova Explosion. A supernovae explosion may end up forming a neutron star or a black hole at its centre.

In cases, when the object produced at the centre is a rapidly spinning black hole, two powerful jets of material stream out along the hole's rotation axis. When one of the jets is directed towards us, we see a bright flash of gamma rays lasting a few seconds. These are called Gamma Ray Bursts. At their peak, they are the brightest gamma ray emitting objects in the universe. Interaction of the fast moving ejecta with the surrounding interstellar matter produces gradually fading Afterglow at all wavebands.

Scientists at IUCAA are studying these afterglows at optical and radio wavelengths to determine the energy content of the outbursts and the density of surrounding matter. Both these can help determine what type of stars produce the GRB events.

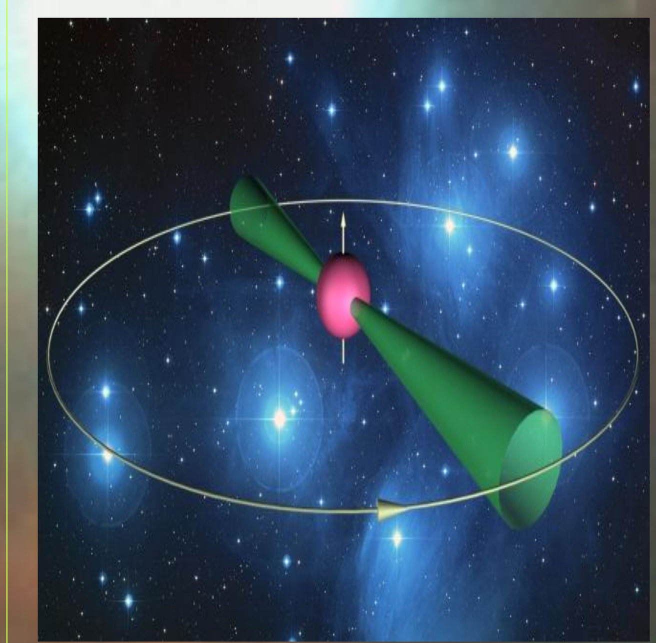


The optical light curve of GRB030329. The red points are observations done in India and blue points are from the rest of the world. The green line shows a standard GRB model. Excess emission due to associated supernova is seen at late times.



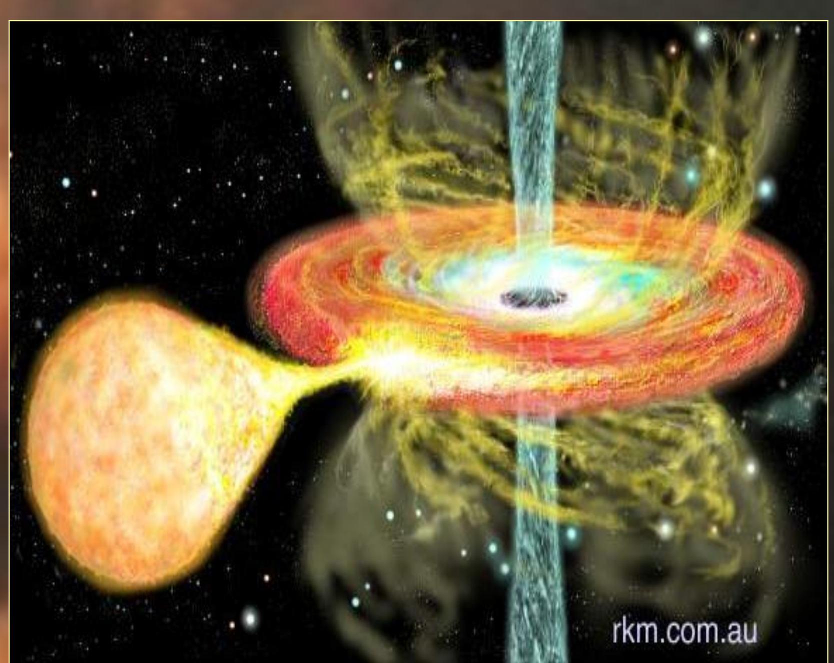
Pulsars

A typical Neutron Star produced in a stellar collapse would possess a strong (Teragauss) magnetic field and very rapid spin (period ranging from milliseconds to seconds). They produce strong, beamed radio emission from their magnetic polar regions.



As the beam sweeps past us, we see a pulse of the radio emission - such objects are called Pulsars. These are among the most accurate known clocks. It is estimated that our galaxy contains about 100,000 active pulsars, only about 2000 of which have been detected by us so far. Scientists at IUCAA and NCRA are jointly conducting a deep survey with the GMRT to find more such pulsars. The study of radiations coming from pulsars are helpful in probing the extreme conditions of highly magnetized dense medium.

Black Holes and X-Ray binaries



Matter from a regular star, may be stripped off and captured by a nearby neutron star or black hole. This matter does not fall directly to the neutron star or black hole, but instead spiral down, forming a disk, called an accretion disk (see Figure above).

The inner region of an accretion disk produces a large amount of X-rays and Gamma-Rays. Since X-rays are absorbed by the earth's atmosphere, these systems can only be observed by using detectors on board on satellites (See Figure on the top right). At IUCAA, theoretical models of accretion disks are developed and the expected spectra and variability are then compared with the observations.

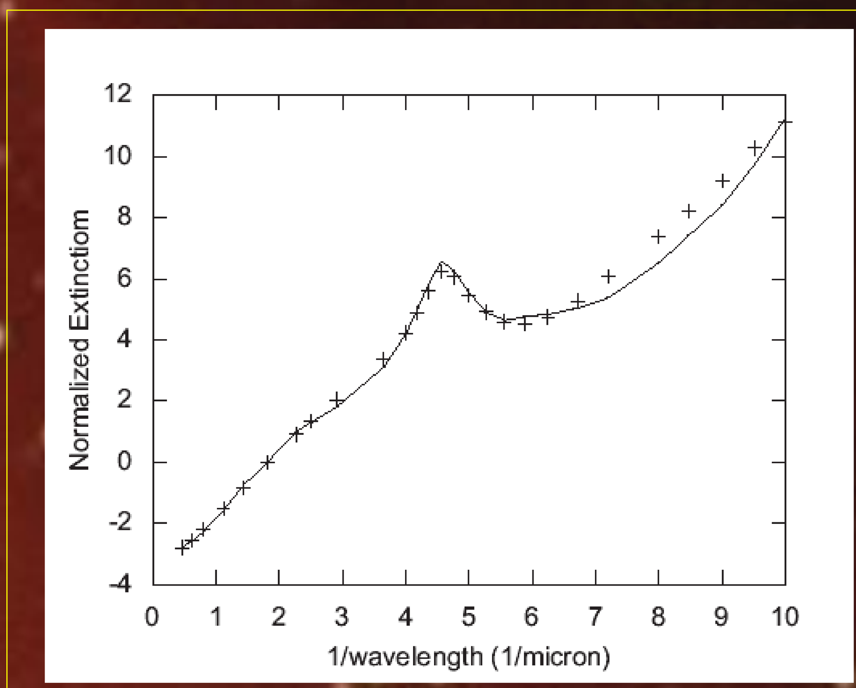
Some of the recent highlights of our studies have been:

i) Mathematically defined chaotic behaviour is exhibited by several natural systems like the weather, human heart etc. It was found that the time variation of a black hole X-ray binary is also chaotic.

ii) The X-ray spectra of black hole systems may have some contribution from the interaction of energetic protons. Such studies may eventually allow us to test the laws of physics (like Einstein's General Theory of Relativity).

Interstellar Dust and Extinction

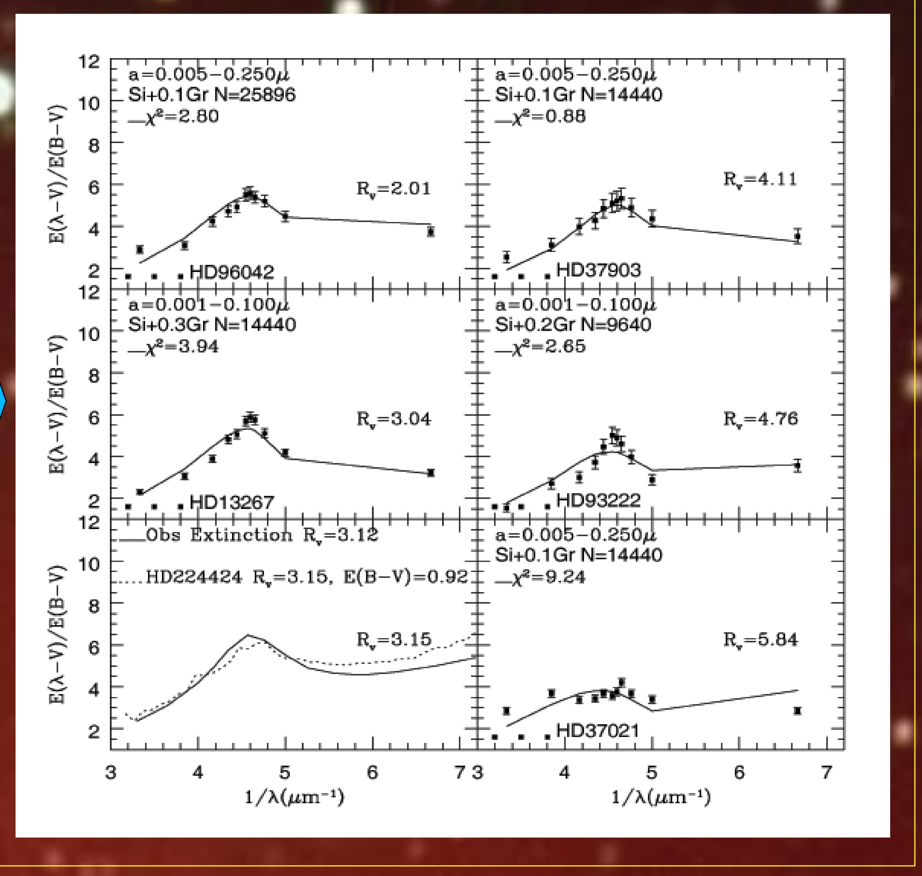
Dust constitutes 1% of the mass of ISM. It plays the most important role in which the light seen form stars suffers extinction (absorption as well as scattering). Recent space probes have confirmed that the dust grains are highly porous and fluffy (i.e. aggregates or clusters) rather than having regular shapes (spherical, cylindrical or spheroidal), homogeneous in composition and structure. Composite fluffy dust grains have been used to explain the observed interstellar extinction curve.



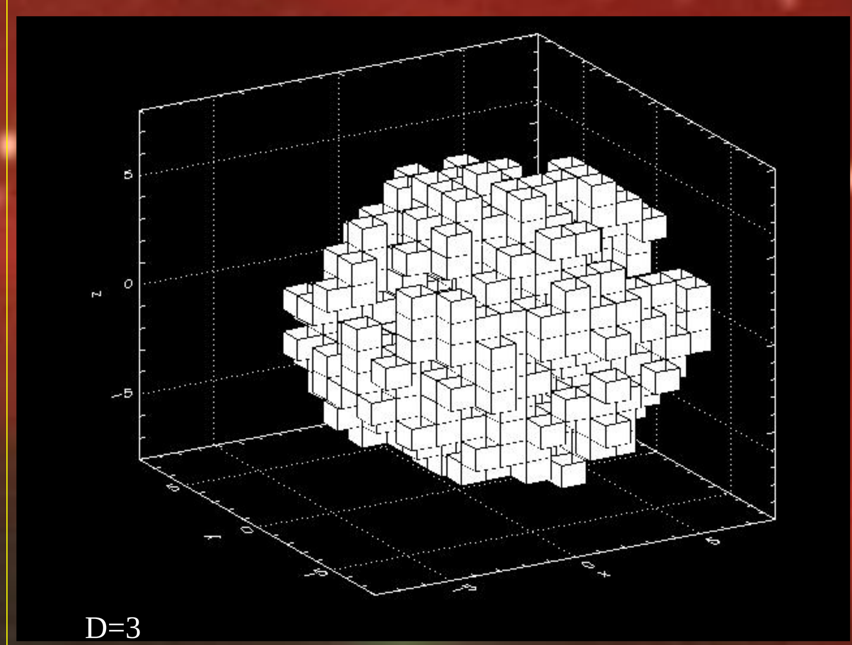
A comparison of the observed average interstellar extinction data (solid line) and the one obtained using an analytical formulas (points). Wavelength range covers visible and infrared regions.

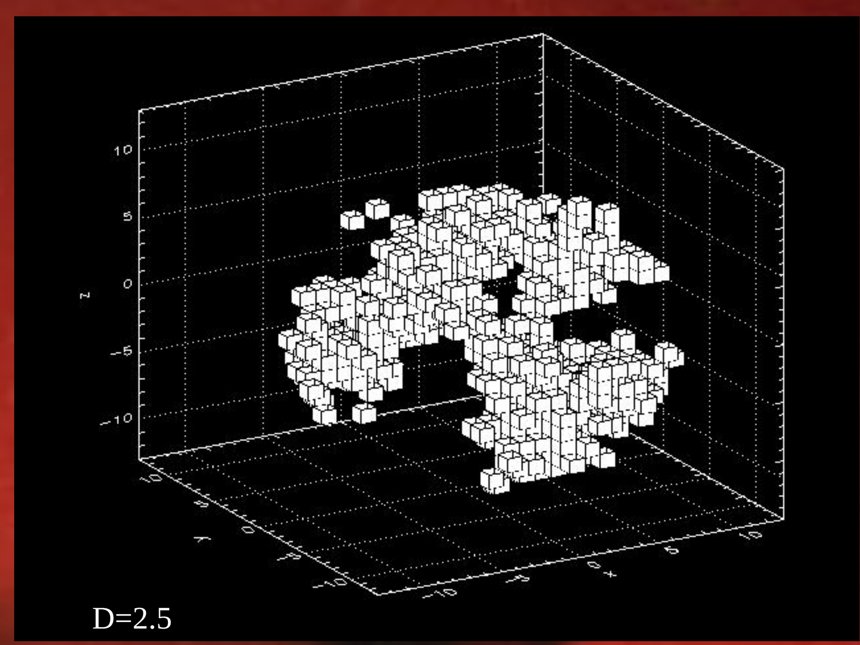
Ref: Roy et al. JQSRT 111 (2010) 795

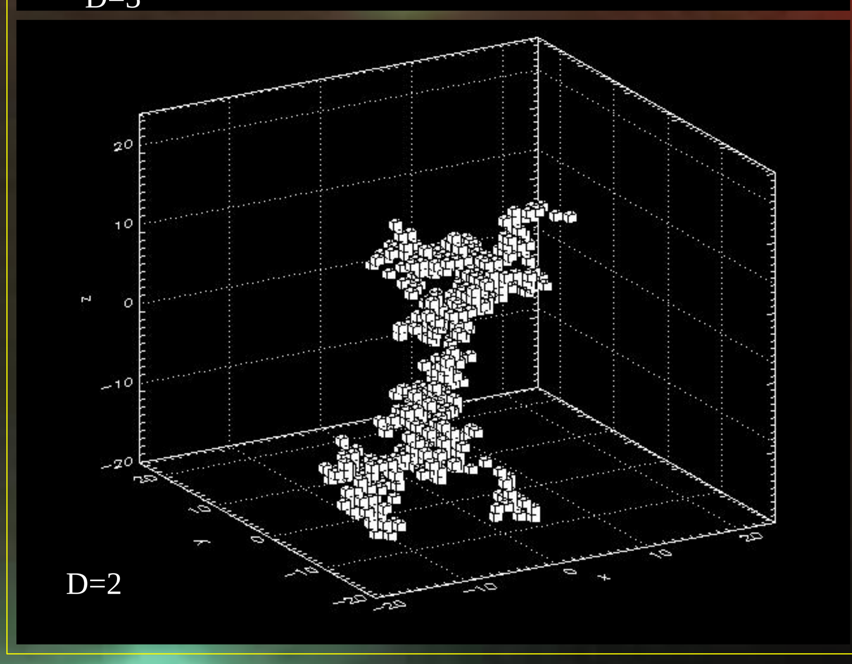
The figure on the right show the fitting of the observed extinction of the starlight due to dust. The model assumes Silicate as the host and graphite as the inclusions in the grain. The Ratio Rv=A(V)/E(B-V) i.e. visual extinction to the total extinction towards the direction of these IUE observed stars is well correlated with the '2175Å' feature. The 'peak' is higher for low value of Rv (2-3) and gets lower for large value of Rv (4-6).



Fractal aggregates of Dust grains

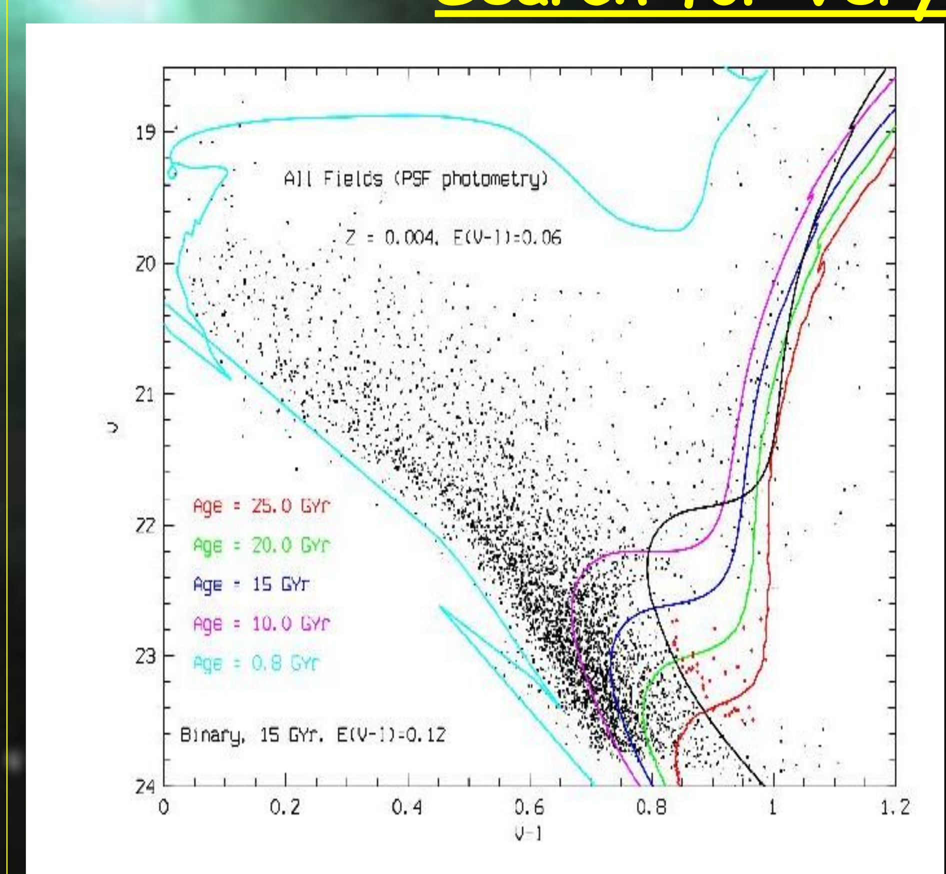






These are simulated fractal aggregates of dust particles of different dimensions which are formed by the process of coagulation and takes millions to years to form. These are primarily responsible for the formation of proto-planetary disk during the planet formation. We calculate the opacities of these structures and hence find out the mass of the dust disk in a protoplanetary disk.

Search for Very Old Stars!



A color magnitude diagram alongside is a very powerful tool that allows us to know about star's life, age, composition and future.

On such a diagram, one can plot lines called "isochrones". Stars lying on these lines have the same age.

About 42 objects have been identified from the LMC (Large Magellanic Cloud) HST data which cannot be explained as lying on ischrones corresponding to the accepted age of the universe (13.7 G Yr).

These very old stars can be:

a) Stars of higher metallicity

b) Pre-main sequence stars i.e. stars being formed.

c) Distant stars in the LMC halo.

d) Stars undergone excess redenning due to local LMC dust. OR

e) Stars older than our universe!

Future observations are required for confirming one of the above scenarios. If it is found that these stars cannot be fitted by the alternate explanations, these stars become older than the accepted age of the universe.