DISTANT GALAXIES AND COSMOLOGICAL MODELS

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Updated February 19, 2007

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February 19, 2007 — Dark Energy
The mysterious substance, dark energy, makes up some 75% of the universe's substance and is seen as responsible for the fact that the expansion rate of the universe is speeding up, not slowing down as gravitational forces alone would do. In Scientific American Magazine for February, 2007 is an article on dark energy

indicating that it appears the dark energy had a lot to do with the formation of galaxies and galaxy clusters as well. *New Scientist* magazine for February 17-23, 2007 has a very good article on the latest thinking about dark energy discussing possible experimental tests and various concepts of what it might be.

January 29, 2007 — Spinning Einstein
In an article in the New Scientist Magazine for January 20-26, 2007 it has been suggested that our universe has a very, very small departure from the rules of special relativity. The new theory is called very special relativity or VSR. VSR concerns the question of rotational symmetry of our universe and involves considerations of neutrinos. The departures from special relativity are exceedingly small. Perhaps, in a few years some experiments will be sensitive enough to look for the effects, they aren't now.

November 26, 2006
Physicists have been looking for a "Theory of Everything", a single theory to tie together quantum mechanics and the rest of physics including gravitation and relativity theory. Much work has been done on "string theory" but so far no results leading to an experimental test. Some enormous number of possible solutions are indicated. Esquire Magazine for December 2006 has an article entitled "The theory of Everything." which reviews the status of the theory and some alternatives and is a good review and synopsis. There is some hope that when the Large Hadron Collider is expected to come on line in spring 2008 in Geneva there will be some new findings that will be helpful.

September 1, 2006
NASA finds direct proof of the existence of dark matter. Dark matter and normal matter have been wrenched apart by the tremendous collision of two large clusters of galaxies. This discovery gives direct evidence of the existence of dark matter since it can be observed directly when away from the luminous matter of a galaxy or galaxy cluster. These results are being published in an upcoming issue of the Astrophysical Journal Letters. Look up "dark matter" on the web as well. There is also an article on this work in Science News for August 26, Vol. 170 no. 9, and a good article in the Stanford Report for August 23, 2006.

September 1, 2006
Results are coming in from the Stanford/NASA satellite, Gravity probe B designed to check the predictions of general relativity. Since August, 2004, massive amounts of data (over one terabyte) have been obtained and have been processed exhaustively. The results of this data analysis are now being very carefully reviewed by Stanford and NASA scientists. Several conferences are scheduled for the near future. The final results and the confirmation or otherwise of predictions of general relativity are expected to be announced publicly next April. See "gravity probe B" on the web as well.

March 24, 2006
Latest analysis of CMBR data from the NASA WMAP satellite (Wilkinson Microwave Anisotropy probe) launched in 2001 and now one million miles from earth. The WMAP satellite has been recording data on the spectrum of the cosmic microwave background radiation (CMBR) with unprecedented sensitivity (recording temperature fluctuations of one millionth of a degree) and unprecedented angular resolution as well, examining the fine-scale structure of the CMBR. The results are now in. They

fully support the previous concepts including the idea of an extremely rapid expansion called inflation. an age of the universe of 13.7 billion years,a universe of 4% ordinary matter, 22% dark matter, and 74% the mysterious dark energy. The voluminous data are a very strong support to the cosmological picture described above.

September 1, 2005
New CMBR measurements question the standard model

Scientific American magazine for August 2005 carries an article entitled "Is the Universe out of Tune?" New, careful measurements of the frequency spectrum of the cosmic microwave background radiation (CMBR) have been made. In addition, measurements have been made of the variations in this temperature pattern in different directions of space. The results do not quite agree with what has been expected in the standard cosmological model with its cold dark matter and dark energy. Either there is something wrong with the way the measurements have been made and interpreted or we are in for a major rethink of the standard model. Hold your breath! Current data are from the US WMAP satellite and there will be more data from it. In 2007 the European Space Agency will launch the Planck mission with greater resolution and frequency coverage.

March 29, 2005
Misconceptions about the big bang

There is an article in Scientific American for March 2005 entitled "Misconceptions About the Big Bang" by Lineweaver and Davis. It points to 6 common misconceptions about the meaning of the expansion of the universe. The proper concepts are:

1. The big bang was not an explosion in already existing space, it was an expansion of space itself.
2. Galaxies' recession velocities are not limited to the speed of light, galaxies can recede from us at velocities greater than the speed of light.
3. We can see galaxies receding at velocities greater than the speed of light.
4. The red shift is not due to the Doppler shift but due to the waves being stretched as they propagate.
5. With an age of some 14 billion years, the observable universe is not limited to 14 billion light years but to some three times that much, about 45 billion light years.
6. The expansion does not cause material objects like galaxies to grow, it is the space between such objects that grows.

This web site is in agreement with all these points and discusses them.

December 26, 2004
Explanation of the concept of critical density

At the end of the section on general relativity there is a note on the meaning of **critical density** and how it may hold as the universe continues to expand.

July 10, 2004
Origin and fate of the universe

Astronomy Magazine has issued as special cosmology issue "Origin and Fate of the Universe" This is an excellent update on cosmology. In addition to its discussion of dark matter and dark energy, it discusses string theory and its application to cosmology and the concept of our universe being created by the collision of two membranes in higher order space. A concept called quintessence is proposed as an alternative to a cosmological constant. All of this with no mathematics.

May 27, 2004
Space is flat and the universe is 13.7 billion years old

Just published in Physical Review Letters are the results of a detailed look at the cosmic microwave background radiation, CMBR, in a search for paired circles which would suggest a positively curved space where we would see the same configuration in two opposite directions. No such effect was found - further supporting the view that space is flat. This supports the view that there is a nonzero cosmological constant and that the expansion of space is accelerating, consistent with our Model V. With an age of the universe since the big bang of 13.7 billion years and an accelerating universe, the furthest present position of an object whose first light is just getting to us now is 78 billion light-years so the diameter of the region we can in principle see now is a whopping 156 billion light-years. These results are discussed on the web in Yahoo news, science - space.com.

March 10, 2004
Results of Hubble deep field survey

The Space Science Research Institute in Baltimore has just announced the results of a Hubble deep field survey in which date were taken for 1 million seconds of a small spot in the sky in both visible and infrared emissions._Galaxies were found whose light has been traveling to us for more than 13 billion years, from a time less than 700 million years after the big bang_itself, estimated to have occurred 13.7 billion years ago (more than 95% of the way back to the beginning)._These results will be analyzed for many reasons for a long time. They will check ideas about the formation of galaxies in the early universe and check our concepts of dark matter and dark energy. Red shifts of 7 have been found and greater redshifts may show up.

French and Swiss astronomers have just announced detection of a distant galaxy whose light has been traveling toward us for 13.23 billion years, only 470 million years after the big bang itself occurring 13.7 billion years ago. This is looking back 96% of the time to the big bang.

February 22, 2004
The cosmological constant is really constant

Our Model V describes a universe in which there is a cosmological constant or "dark energy" which opposes gravitational attraction and has a value such that the universal expansion is now speeding up rather than slowing down. See the discussion of Model V of this web page. Previous observations of super novas have indicated the existence and magnitude of this term. Some astronomers feel that perhaps it is not a constant but is either growing or shrinking with time. Dr. Adam Riess of the Space Telescope Science Institute and associates have just presented the results of the most recent and most precise measure of supernova distances and

recession velocities using data from the Hubble Space Telescope. The results indicate that the cosmological constant has changed very little if at all during the life of the universe.

February 14, 2004
CMBR, galaxy formation and galaxy clusters, dark matter, dark energy

Scientific American Article
The February 2004 issue has a special report, "Four keys to Cosmology." The articles discuss the cosmic background radiation (CMBR), the formation of galaxies and galaxy clusters and the evidence for dark matter, the speedup of the expansion viewed as evidence for "dark energy" and some thoughts about possible other explanations than dark energy for the cosmological expansion. The comments about CMBR, dark matter and dark energy are consistent with the presentation of Model V of this site.

October 20, 2003
The shape of space, it_s flat

Dr. Adam Riese, an astronomer at the Space Telescope Science Institute, has announced that more very distant supernovas have been observed and they indicate that the expansion of the universe has been speeding up since about 5 billion years ago. This acceleration is due to dark energy, a repulsive force, astronomers have been studying. These results are consistent with earlier findings and are consistent with Model V of this web page (see menu at left).

And now a very strange new development. Another study of the cosmic background radiation, CMBR, by Jeffrey Weeks and coauthors reported in Nature has supported previous work on small scale fluctuations_in CMBR intensity, but has found that at large angles, the fluctuations are much smaller than expected. Rather than supporting the concept of flat space and an infinite universe, they feel that the data support the concept of space in the form of a dodecahedron, a twelve sided volume bounded by pentagons. This is a very strange result indeed and will invoke much discussion and further research.

August 2, 2003
Evidence of the presence of dark energy

There is an article of interest in Science News, Vol. 164, No. 5, August 2, 2003, entitled "Repulsive Astronomy". Extremely detailed measurements of the cosmic background radiation have been made and the wavelengths from the radiation passing through galaxy clusters is slightly shifted indicating the presence of a repulsive force, the dark energy of the cosmological constant. This is an independent way to check the existence of the dark energy and is a further substantiation of the current cosmological model which is Model V of this web page.

February 18, 2003
WMAP data _ 4% ordinary matter, 23% dark matter, 73% dark energy

The latest measurements of the cosmic microwave background, CMBR, by a NASA satellite, WMAP, are far more sensitive and of much higher resolution than any

previous work. The results indicate an age of the universe of 13.7 billion years with a 1% accuracy, a composition of 4% ordinary matter, 23% dark matter and 73% dark energy (the cosmological constant) and flat space. Verification of the big bang and the time of 380,000 years later when energy could freely stream through space and a time of 200 million years for first star formation were also deduced from the data. Science News. Volume 163 No 7, February 15, 2003. These findings are supportive of the Model V of this page. The article concludes "The most profound result is that everything fits with the current cosmological model. For the first time, we are making measurements with such precision that we have a standard model for the evolution of the universe in the same way that particle physicists have a standard model of the subatomic world."

January 1, 2003
Hubble constant at km/sec/megaparsec, flat space, age 13±1 billion yrs

The magazine American Scientist for January-February of 2003, Volume 91, No. 1 carries an excellent article entitled "The Hubble Constant and the Expanding Universe." It is a detailed update on the latest measurements of the Hubble constant and gives it as 72 kilometers per second per megaparsec. The article also discusses the Friedmann equation of general relativity which relates the Hubble constant to the mass density of the universe (including dark matter) the curvature of space and the cosmological constant. It gives a best value of zero for the curvature (flat space) 0.3 for the mass density term and 0.7 for the cosmological constant term. The resulting age of the universe is given as 13 ± 1 billion years as the present age of the universe and indicates that the expansion rate is now speeding up.

All of these points are consistent with and supportive of Model V of this web page. The Friedmann equation and the mass density, space curvature and cosmological constant terms are described in Appendix III

So, in summary, the latest data indicate a Hubble constant of about 72, an age of the universe since the big bang of 13 ± 1 billion years and a universe whose expansion rate is now speeding up.

October 11, 2002
Polarization of the CMBR

Polarization of the Cosmic Microwave Background Radiation CMBR *Science News* for September 28, 2002, has a brief report on new measurements of the CMBR. Previous measurements focussed on measuring the angular size of tiny variations in the intensity of the radiation. The results are consistent with our Model V with a positive cosmological constant and a universe starting with the big bang. These new measurements look at the polarization patterns of the CMBR and again are consistent with the concepts of the big bang, inflation and a universe with a positive cosmological constant. Once again, our Model V seems to be holding up well.

August 9, 2002
Expansion is accelerating from super nova data

Supernovas and an Accelerating Universe

In **Discover** magazine for September 2002 there is an article entitled "The race to discover how the universe will end." It describes the competitive efforts of two

research teams to measure the brightness and redshift of distant type 1A supernovas. The results support the existence and value of the cosmological constant and an accelerating value of the expansion of the universe. These results are consistent with our Model V and figure VIII. (see menu at left)

April 25, 2002
Age of universe 13 to 14 billion years from white dwarf data

Age of the Universe

Speaking at a news conference, Harvey Richer, astronomer at the University of British Columbia said that recent observations of fading white dwarf stars indicate some may be about 12.7 billion years old. If they were formed about 1 billion years after the big bang, the age of the universe is 13 to 14 billion years. This is consistent with other methods measuring the rate of expansion of the universe. There is more confidence in results when two or more independent methods give the same results.

January 25, 2002
Dark matter at about 1/3 critical density for flat space

Dark Matter

It is thought that most of the mass in the universe is in the form of dark matter which cannot be seen directly. A way to detect evidence of dark matter is to see how the light from distant galaxies is bent by an effect called gravitational lensing. A survey of 145,000 galaxies has just been made and it suggests dark matter of an amount consistent with previous estimates (and with Model V of this web page). From the motions of stars in a rotating galaxy it appears that there is generally a halo of dark matter in these galaxies of greater extent and mass than the visible stars indicate. It is now thought that there may be galaxies which contain only dark matter, no visible stars at all.

The presence and amount of dark matter in halos around galaxies and in the space between galaxies in a cluster is estimated from the motions of the stars in the galaxies and of the galaxies in the clusters and is confirmed by the way light bends in passing through dark matter. The amount found from these motions is about 1/3 of the critical mass density. But, is there much more dark matter in the voids between galaxies and galaxy clusters? Is the total amount of dark matter much more than 1/3 critical? A very recent pair of surveys of hundreds of thousands of galaxies has shown that dark matter is distributed pretty much as the visible galaxies are and there is no significant amount of dark matter in the voids so the 1/3 number looks good. See Science News for January 5, 2002, Volume 161 No. 1.

November 5, 2001
Evidence for an age of 14 ± 1/2 billion years

The cosmic microwave background radiation, CMBR

Science News for October 27 (Vol. 60 #17) describes the most recent CMBR measurements indicating an age of the universe as 14 ± 1/2 billion years.

Space is filled with radiation from the very early universe which has traveled so long that the wavelengths have been stretched into the microwave region. The wavelength spectrum has been measured and fits the black body spectrum as predicted. While this radiation is nearly uniform in all directions there are very small ripples in intensity of various angular sizes. Present theory predicts that if space is flat, the angular spectrum should have a peak at about one degree and should also have harmonics at 1/2 and 1/3 degree and so on as well. There have been several experiments to measure this spectrum and more are underway now. The one degree peak is well substantiated and some earlier experiments have indicated a 1/2 degree peak while others have not clearly shown it. Project BOOMERANG was a balloon flying high above Antarctica. The first data confirmed the one degree peak. Data analysis is continuing, examining secondary peaks. MAXIMA was another balloon project over Texas and it has confirmed the first peak. There have been ground-based measurements as well from a project called Degree Angular Scale Interferometer (DASI). On Sunday, the three teams announced that their date now show clearly not only the I degree peak but also the second and third harmonic. This further strengthens the case for a flat universe and is consistent with the big-bang theory. The most exciting future development is that a satellite called MAP (microwave anisotropy probe) is scheduled for launch this summer and it will have much greater sensitivity and angular resolution than the other experiments and should produce an enormous amount of data. Its data should confirm secondary peaks and could check the flatness of space, some aspects of the concept of inflation in the early universe, the quantity of matter (both ordinary and dark) in the universe and even the value of the Hubble constant. Perhaps the data might even question the concept of the big bang itself. A very exciting time in the next several years for cosmology!

July 28, 2001
Concepts of astronomical distances

The August 2001 issue of *Sky and Telescope* has an article titled "Another Look at Cosmic Distances" It discusses the various concepts of distances described in this web page and gives an overview of latest evidence supporting our Model V.

Time Magazine Article

Time Magazine for June 25, 2001 has an article titled "How the Universe Will End" giving the latest data from supernova observations and from the structure of the cosmic microwave background radiation, CMBR. The results are quite consistent with Model V of this web page in terms of the flatness of space, the amount of dark matter and dark energy and the present acceleration of the expansion.

January, 2001
The cosmological constant, is it constant?

The Cosmological Constant

The cosmological constant is thought to represent the energy density of empty space and is taken as a constant density even as space expands. There is new thought about a possible alternative called quintessence which might behave slightly differently. A good description of the situation is in the Scientific American for January 2001. In the next few years, there may be experimental evidence to indicate

which concept fits observations better. A very good book on cosmology has just been published, "Just six Numbers" by Martin Rees with quite a discussion of the cosmological constant as well as mass density and space curvature. Recent analysis of the x-ray spectrum from spinning neutron stars seems to be supportive of the concept of frame dragging which is one of the predictions of general relativity on which present cosmology is based. Frame dragging is the effect where a heavy chunk of spinning matter wrenches the space-time around it like an eggbeater. This modifies the spectrum of the x-ray radiation from the star. The evidence is circumstantial and more observations and interpretations are being made.

URL this site: http://www.CosmologyModels.com