Tests and problems of the standard model in Cosmology

Martín López-Corredoira

Instituto de Astrofísica de Canarias
(Tenerife, Spain)

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Dogmas of BIG BANG

- Redshifts due to expansion
- CMBR produced at decoupling matter-radiation at $z \approx 1100$
- Abundance of light elements produced in primordial nucleosynthesis
- Formation and evolution of galaxies and large-scale-structure produced

by gravity including dark matter and dark energy

Expansion of the Universe

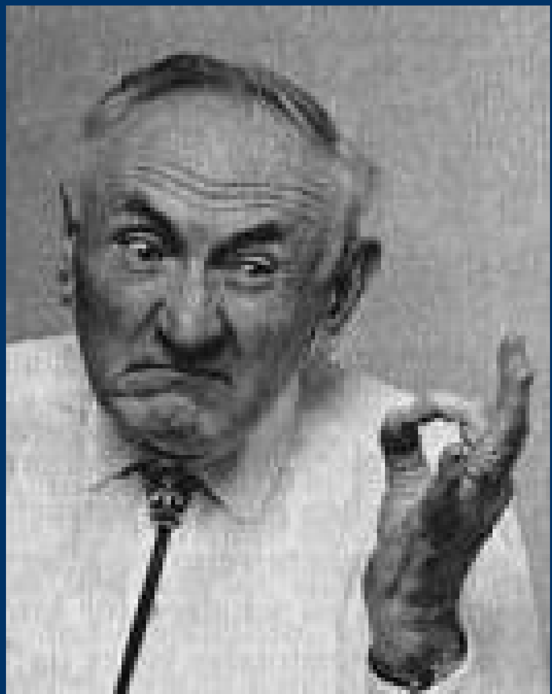
1)Does redshift mean expansion?

Edwin Hubble (1889-1953)

“It seems likely that red-shifts may not be due to an expanding Universe, and much of the speculation on the structure of the universe may require re-examination” (Hubble 1947)

Expansion of the Universe

1)Does redshift mean expansion?



Fritz Zwicky (1898-1974)

Tired light hypothesis:

Proposed by Zwicky in 1929:

$$E(r)=h\nu(r)=h\nu_{emisión}\, e^{-H_0\, r/c}$$

Due to the interaction of the photon
with matter or other photons,
it loses energy (E) along its path;
therefore, it loses frequency (ν), i.e.
a redshift is produced.

Expansion of the Universe

1)Does redshift mean expansion?

Tired light. Problems:

- The interaction of the photon should not give a straight path, so blurring is expected in the images.

- Scattering depends on frequency.

Tired light. Recent solutions:

- Interactions in "Raman" coherent scattering with atoms of H in state 2s or 2p (Moret-Bailly; Gallo); or with electrons (Marmet & Greber)

- Scattering when crossing an inhomogeneous and turbulent plasma (Wolf; Roy et al.) [blurring]

-Interference with vacuum excitations, which behave as an ether (Vigier); or grav. interaction with wave packets of the space-time curvature (Crawford) or with gravitons (Ivanov; van Flandern)

Expansion of the Universe

1)Does redshift mean expansion?

Other solutions in terms of gravitation:

- Ordinary gravitational redshift of general relativity (Bondi; Baryshev) between two regions of different potential; differences of Weyl curv. of space-time between two regions (Krasnov & Shtanov)

- Inertial induction (machian) in which the gravity depends on the relative velocity and acceleration between two Bodies (A. Ghosh)

- Gravity quantization (Broberg)

Variable mass, time,...:

- Variable mass in particles (Hoyle & Narlikar)

- The photon looses energy because it emits other photons of lower energy (3 K?) (Roscoe; Joos & Lutz)

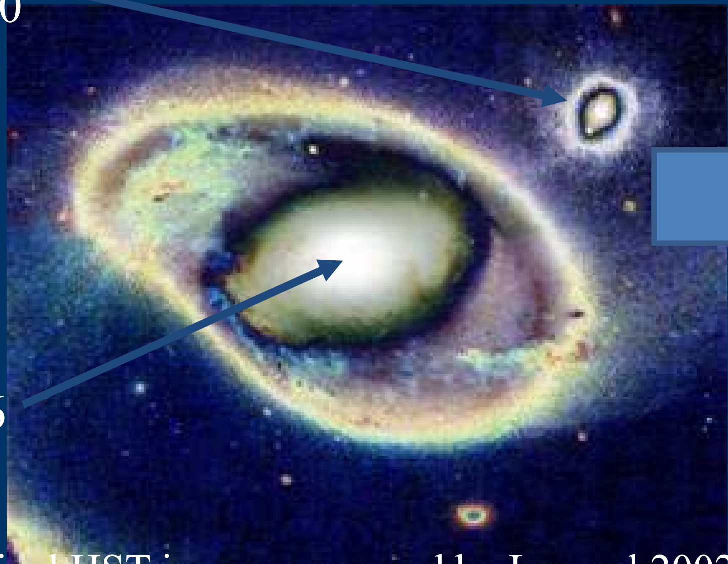
- Photon has mass (Roscoe) and it grows secularly (Barber).

- Time acceleration (Garaimov); local shrink-age of the quantum world (Alfonso-Faus); time variation of speed of light (Alfonso-Faus); quantum long time enery redshift (Urbanowski); etc.

Expansion of the Universe anomalous z?

QSO
z=0.070

NGC 4319+Mrk 205



z=0.006

Original HST image processed by Lempel 2002

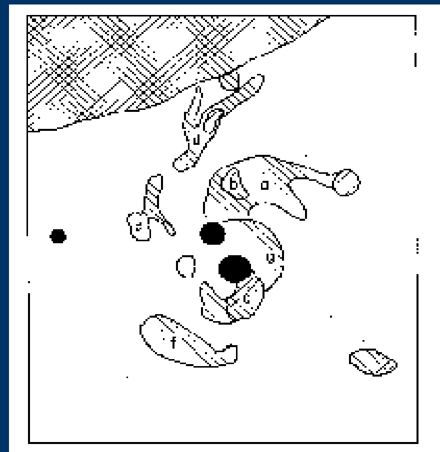
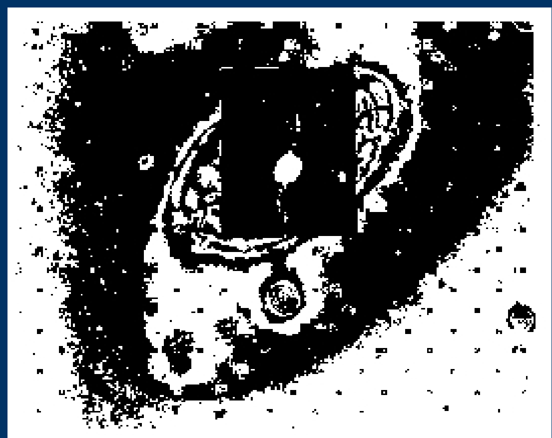


Diagram of features observed in the median filtered image by Cecil & Stockton (1985)



High-pass filtered image (Sulentic & Arp 1987)

	EXPANSION	**STATIC**
$T_{CMBR}(z)$	**Good fit.**	Tired light redshift of a CMBR coming from very high z.
Time dilation	**Good fit** for SNIa. Unexplained absence of time dilation for QSOs and GRBs.	Selection effects, or ad hoc modification of the theory or the zero point calibration, or evolution of SNIa periods.
Cosmic chronometers	**Good fit** but by chance, measurements of differential age are incorrect.	Bad fit but measurement of differential age are incorrect.
Hubble diagram	**Good fit** but requires the introduction of dark energy and/or evolution of galaxies.	**Good fit** for galaxies. **Good fit** for SNIa with some models.
Tolman (SB)	Requires strong evolution of SB.	**Good fit.**
Angular size	Requires too strong evolution of angular sizes.	**Good fit.**
UV SB limit	Anomalously high UV SB at high z.	**Good fit.**
Alcock-Paczynski	Non-good fit for the standard model but good fit with other wCDM models	**Good fit** for tired light.

(López-Corredoira 2015)

CMBR

Success of standard cosmological model?

Succesful predictions:

1. Isotropy
2. Black body radiation
3. Peaks in CMBR power spectrum (Peebles & Yu 1970)

Etc.

Wrong predictions which were corrected ad hoc:

1. Temperature T_{CMBR}=50 K (Gamow 1961) or 30 K (Dicke et al. 1965)
2. Amplitude of the anisotropies ($\Delta T/T \sim 10^{-2}$-10^{-3}; Sachs & Wolfe 1967)
3. Position of the first peak at $l \approx 200$ (measured for the first time in the middle 90s [White et al. 1996] and contradicting the preferred cosmological model at that time $\Omega = \Omega_m \approx 0.2$)
4. Amplitude of the second peak as high as the first peak (Bond & Efstathiou 1987)

Etc.

Non-baryonic dark matter ad hoc

Dark energy ad hoc

CMBR

Other interpretations of CMBR with T=2.7 K

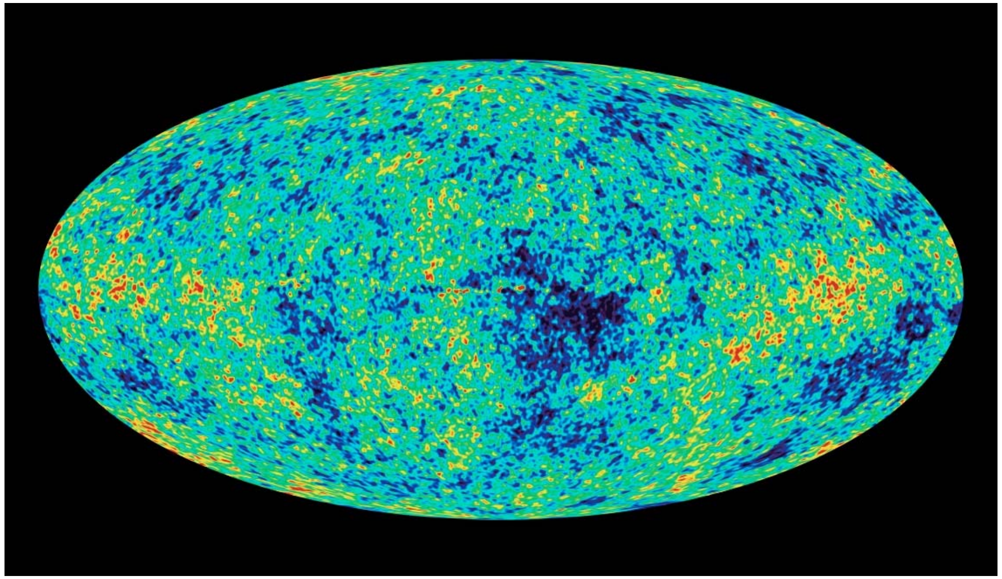
- Due to absorption of radiation of stars and/or cosmic rays, there is a space temperature of 1-6 K.
Guillaume (1896); Eddington (1926) [3 K]; Regener (1933);
Nernst (1937) [2.8 K]; Finley-Freundlich (1954); Bondi et al. (1955);
G. R. Burbidge (1958) [2.76 K]

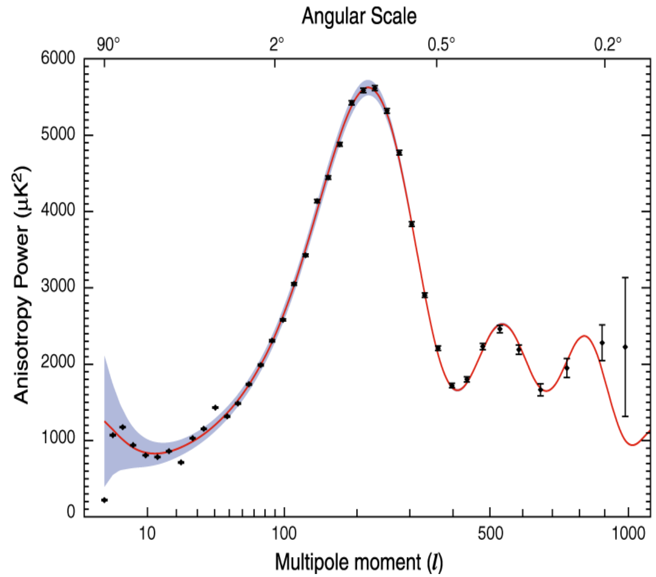
- Clube (1980): an ether which emits CMBR

- Thermalization (black-body spectrum) might be produced by absorption/reemission of whiskers (long-shaped dust) (Hoyle et al.) or by electrons in magnetic fields (Lerner).

CMBR

Anisotropies



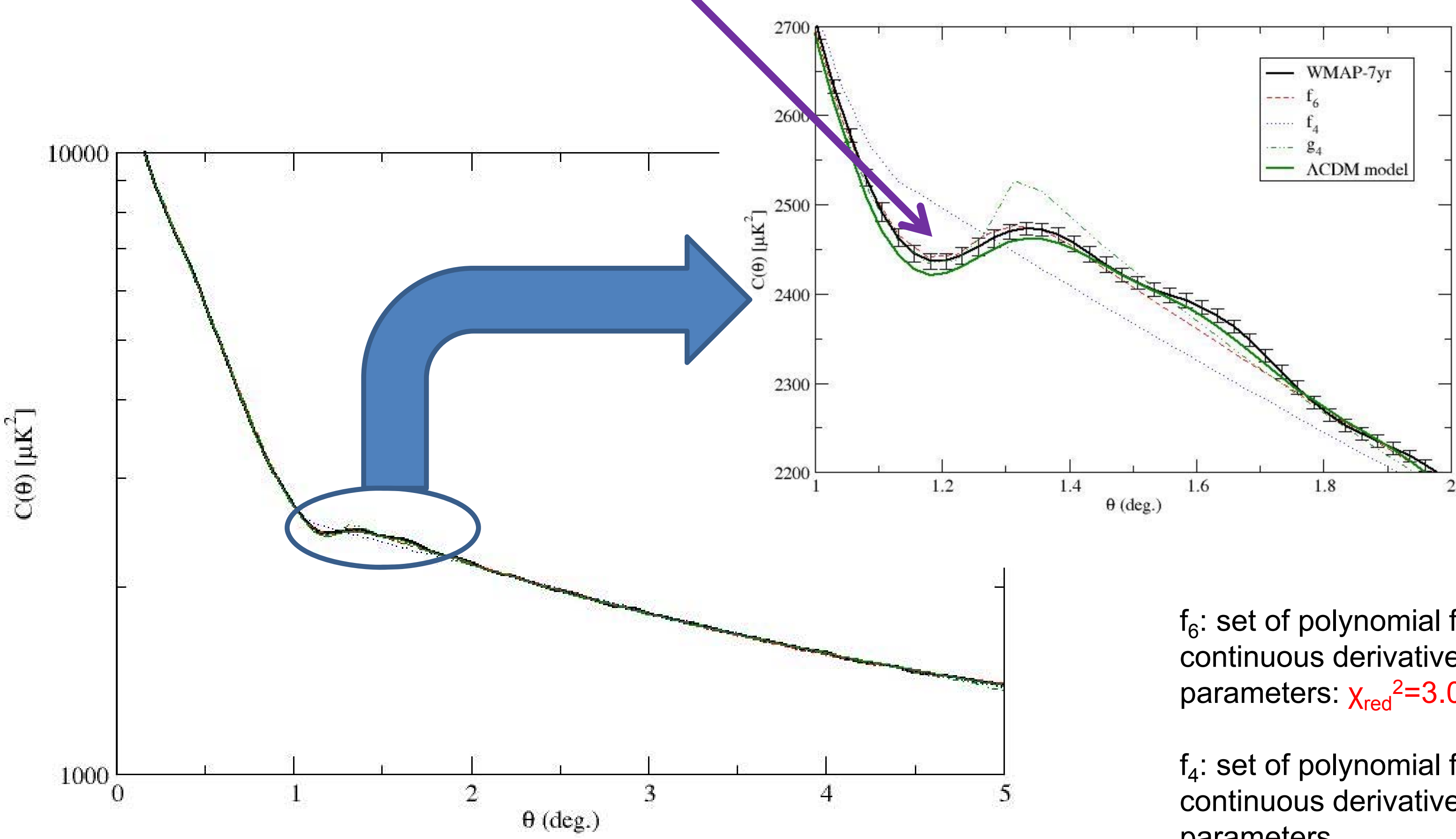


A 10-20 free parameters curve fitted by a 10-20 free parameters model.

CMBR

WMAP-7yr data

Dip = anticorrelation of disks



(López-Corredoira 2013)

f_6: set of polynomial functions with continuous derivative with 6 free parameters: χ_{red}^2=3.0

f_4: set of polynomial functions with continuous derivative with 4 free parameters.

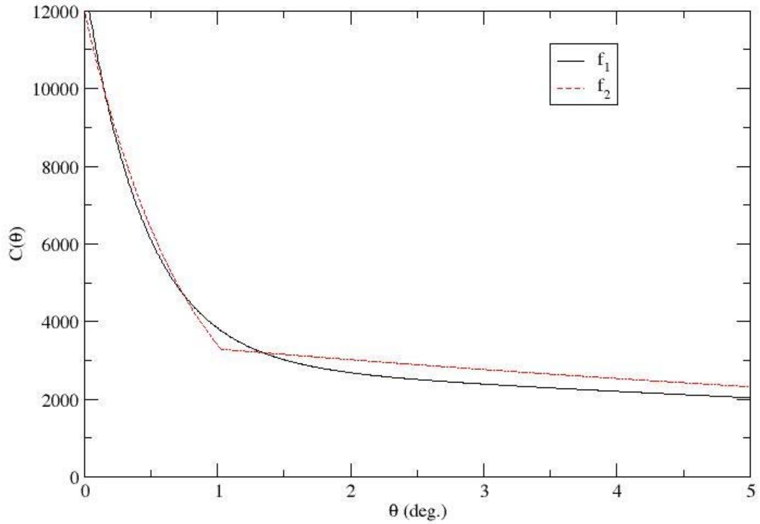
g_4: set of polynomial / logarithmic functions with 4 free parameters.

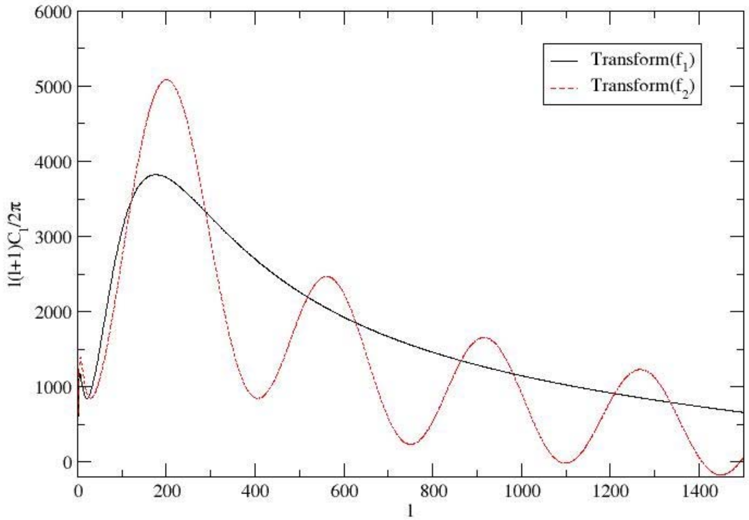
CMBR

Two-point correlation function

(Transform: Fourier/Legendre)

Power spectrum

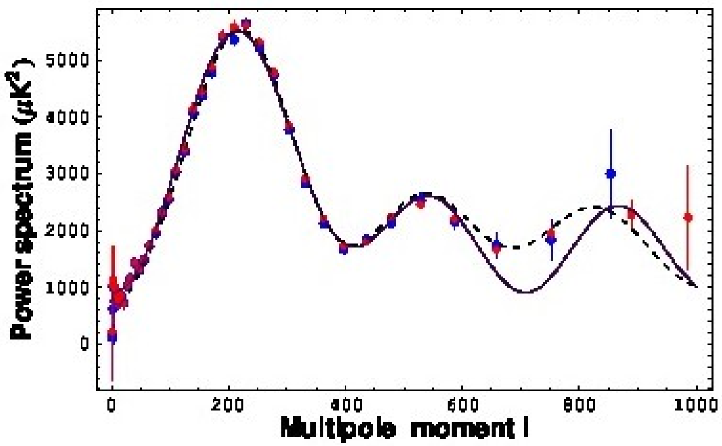


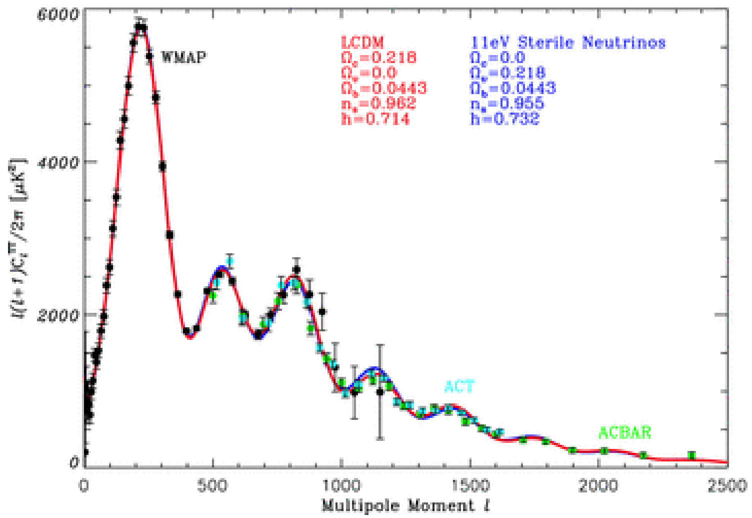


López-Corredoira & Gabrielli (2013)

CMBR

Power spectrum





Narlikar et al. (2007): WMAP-3yr data.
Solid line: QSSC and clusters of galaxies with 6 parameters;
Dashed line: standard model.

Angus & Diaferio (2011): WMAP-7yr+ACT+ACBAR data.
Blue line: MOND, with sterile neutrinos with 6 free parameters;
Red line: standard model.

CMBR

Recipe to cook CMBR in an alternative cosmology

General features of CMBR and its power spectrum/two-point correlation function:	Explanations which do not require the standard model:
1. Temperature T_{CMBR}=3 K	Several ideas (e.g., stellar radiation)
2. Isotropy	Radiation coming from all directions
3. Black body radiation	Thermalization of radiation? Not clear yet
4. Gaussian fluctuations	There are many processes in Nature which generate Gaussian fluctuations; but, there may be non-Gaussianity too
5. Peaks in CMBR power spectrum	Abrupt transition of emission/absorption inside and outside some clouds/regions
6. 6 free parameters should fit it	A simple set of polynomials produce a quite good fit of the 2-point corr.func., but do not explain 3rd peak ≈ 2nd peak amplitude FURTHER RESEARCH IS NEEDED
7. Others (polarization,…)	Pending

Major problem

References: López-Corredoira & Gabrielli, 2013, *Physica A*, 392, 474
López-Corredoira, 2013, *Int. J. Mod. Phys. D*, 22(7), id. 1350032

CMBR

Anisotropies

Some problems:

- Quadruple and octopole aligned and correlated with the (solar system) ecliptic; no enough correlation at low multipoles (>60 deg.; inflation wrong?) (e.g., Starkman et al. 2012).

- Anisotropies distribution is not Gaussian (e.g., McEwen et el. 2008).

- Contamination (even in the foreground substracted maps) of the solar system, of our Galaxy, of the intergalactic medium, of galaxies and clusters of galaxies (e.g. López-Corredoira 2007)

Etc, etc.

Abundance of light elements

1) Primordial ^{4}He: succesful prediction?

- A 24% of primordial (when the metallicity is null, cases in which the stars had not time to produce the synthesis of neither helium nor metals) Helium is observed.

- Alternative explanations: e.g., old stellar population (III) which synthesized Helium (Burbidge & Hoyle) and ejected it to the external layers (without C, O, etc.).

- Critics to the methodology (Kurucz 1992): instead of trying to make predictions that can be tested by observations, cosmologist fit some free parameters to reproduce some given observations.

Abundance of light elements

1) Primordial ^{4}He: succesful prediction?

- More recent and precise measurements of ^{4}He give abundances of 0.2565±0.0010(stat.)±0.0050(syst.) (Izotov et al. 2010), 2σ higher than predictions of Big Bang.

- There are galaxies with abundances of 0.21 (Terlevich et al. 1992).

Abundance of light elements

2) Other elements:

- Deuterium production and evolution mechanism not well understood (Prodanovic et al. 2003).

- Predictions of abundance of Lithium fail (Cyburt et al. 2008, Coc et al. 2012, Famaey et al. 2012).

- Predictions of abundance of Beryllium fail (Casuso & Beckman 1997).

- Standard cosmology says that the measurements do not give primordial abundances (zero metallicity) but there is contamination by elements produced/destroyed in recent epochs.

Baryons

<50% of the baryons (necessary to fit the light element abundances) have been found at low redshift.

Where are the rest of the baryons?

(tentative explanation: filaments in intergalactic medium of cosmic web; Eckert et al. 2015)

Reionization epoch

- Gunn-Peterson trough in QSOs → reionization at $z_r \approx 6$ (Becker et al. 2001)
- Ly-α lines are not strongly suppresed by HI in IGM at z=6.5 → $z_r > 6.5$ (Malhotra et al. 2004)
- Galaxies observed at z>>6 → no opacity features at z>>6 → reinionization at $z_r >> 6$
- CMBR anisotropies: $z_r = 10.5 \pm 1.2$ (WMAP; Jarosik et al. 2011), $z_r = 8.8 \pm 1.2$ (Planck collaboration 2015)

Formation and evolution of structures and galaxies

1) Large-scale structure

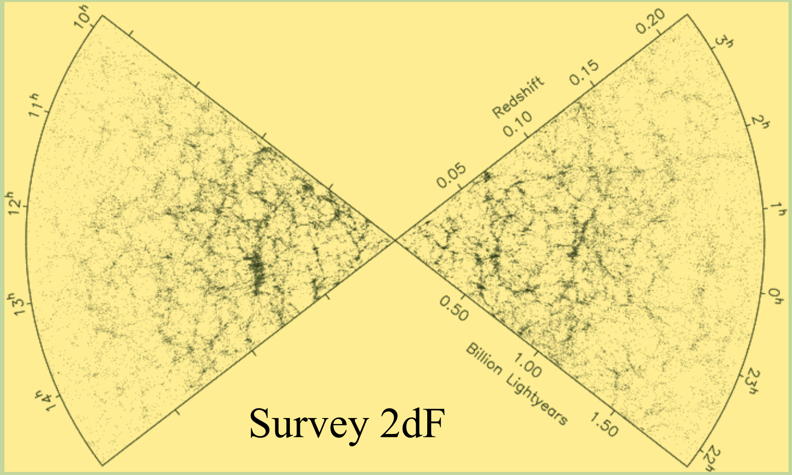
Alternative theories explaining it:

- Quasi-steady State Theory (Nayeri et al. 1999)

- Magnetic fields (Battaner et al. 1997-98) or Plasma Cosmology in general (Alfvén, Peratt, etc.)

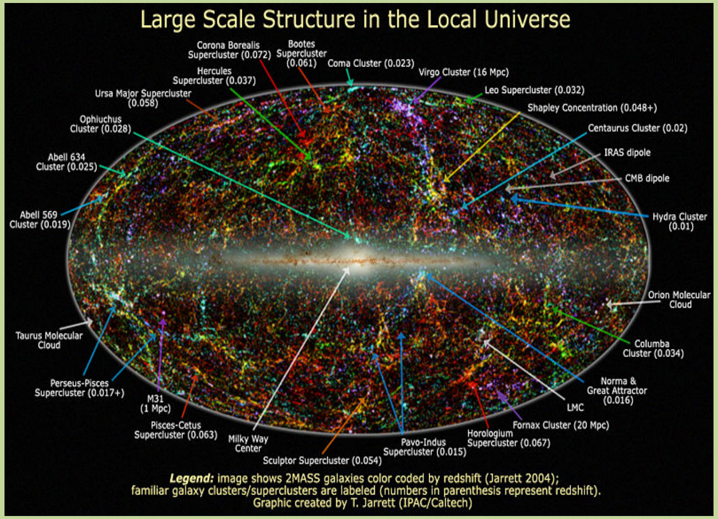
- Radiation given off by primordial galaxies (Kurucz 1992)

- Galaxies beget other galaxies (Ambartzumian, G. R. Burbidge)



Formation and evolution of structures and galaxies

1) Large-scale structure



Some unexpected observations:

- Departure from homogeneity in scales larger than 200 Mpc (Best 2000) [fractal], and structures up to 1000 Mpc (Nabokov et al. 2010)

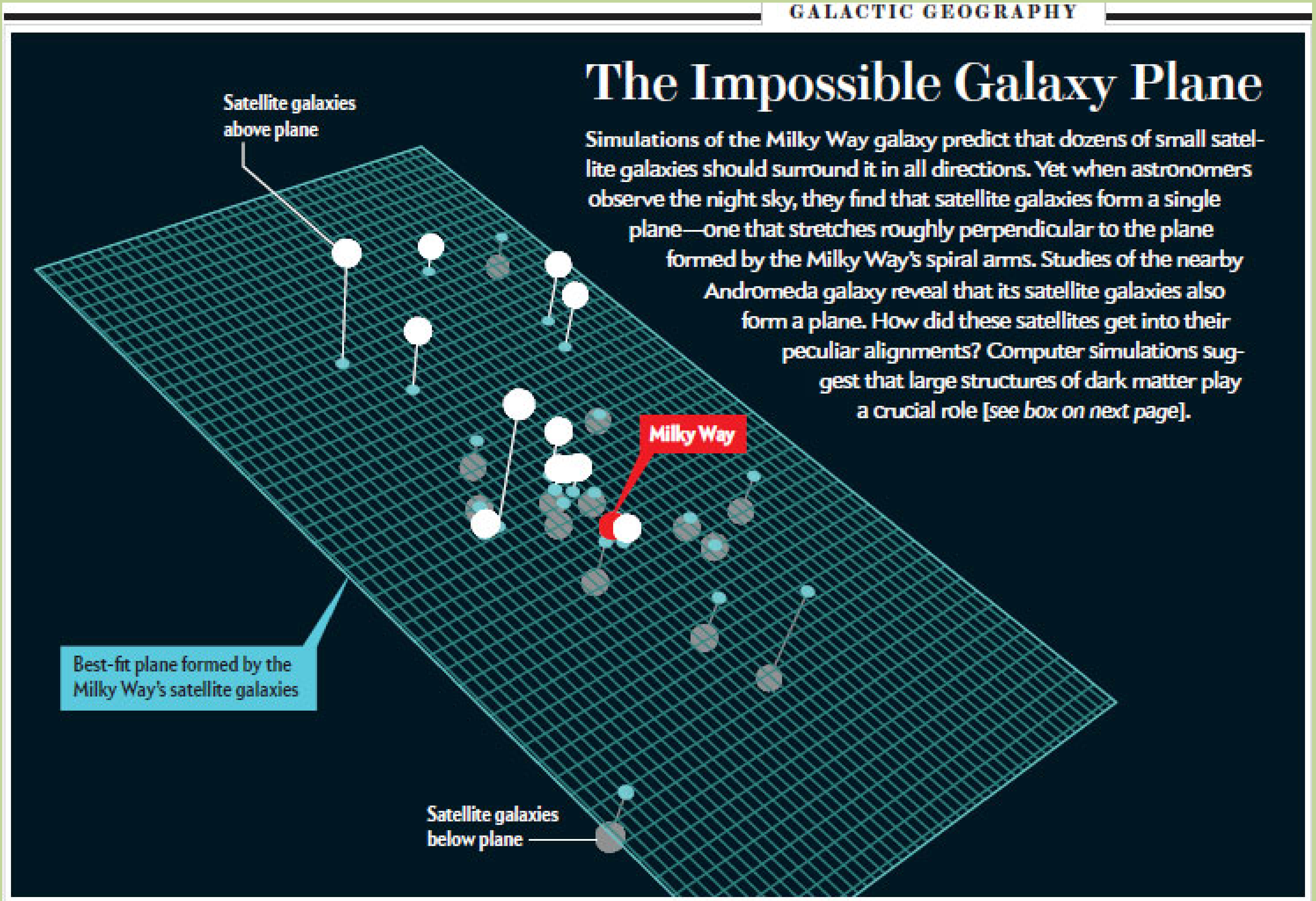
- Periodicity of structures and redshifts (Tifft effect) beyond the expected regularity

- Streaming motions too high for the expected Uniform density distribution: local clusters (Hudson et al. 1999), Bullet cluster (Thomson & Nagamine 2012); CMBR kinetic-SZ (Atrio-Barandela et al. 2015)

- Local void too empty (Peebles & Nusser 2010)

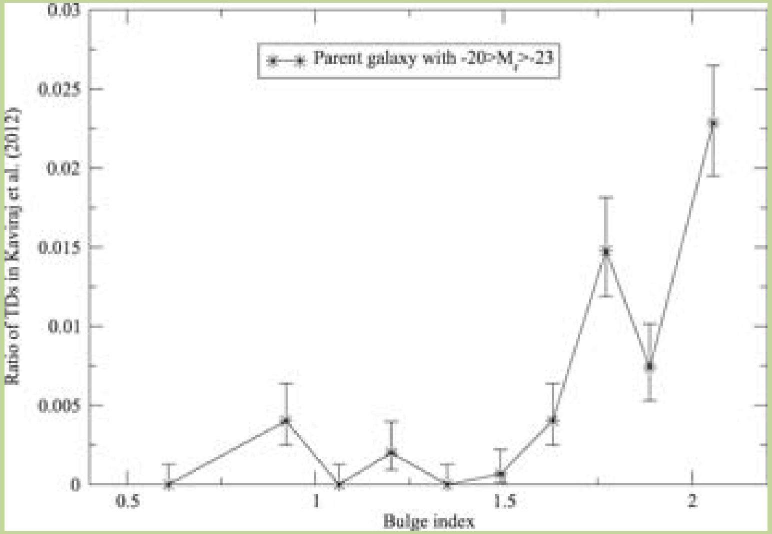
- BAO peak position depending on environment (Roukema et al. 2015)

Formation and evolution of structures and galaxies



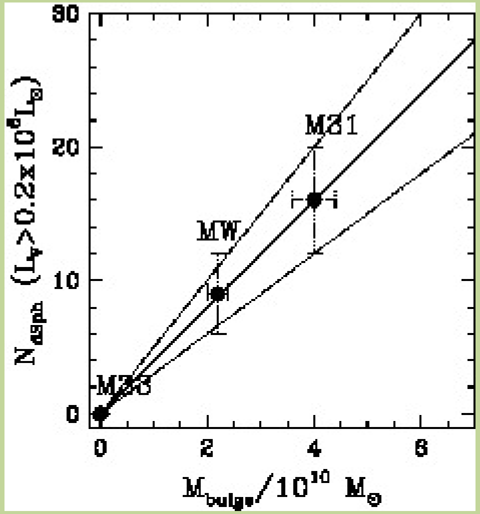
(Libeskind 2014, Pawlowski et al. 2013)

Formation and evolution of structures and galaxies



Constant ratio
excluded at **5σ**
(López-Corredoira & Kroupa 2016)

Local Group
(Kroupa 2010)



Number of TDGs or dSphs
Proportional to bulge size

(as predicted by modified gravity
models and unpredicted by
Standard model with dark matter)

Formation and evolution of structures and galaxies

2) Dark matter

- Problems at galactic scales: no cusped haloes observed, angular momentum of galaxies much higher than predicted, the number of satellites lower than predicted, etc.

- There are alternative explanations at galactic scales: for the galactic stability, warp creation, rotation curves, etc.

- Many attempts to detect the dark matter in form of black holes, brown dwarfs/planets, dissipationless particles, etc. have failed.

WHAT IS DARK MATTER?

Formation and evolution of structures and galaxies

3) Cosmological constant. Dark energy.

Doubts on Ω_Λ=0.7 from SNIa results:

- Intergalactic grey dust (Aguirre & Zoltan 2000; Goobar et al. 2002)

- Evolution of host galaxy extinction (Rowan-Robison 2002; Bálazs et al. 2006)

- Intrinsic variations of SNIa luminosity due to changes in metallicity (Shanks et al. 2002; Podsiadlowski et al. 2006)

- Uncertainties in the K-correction of SNIa (Knop et al. 2003)

- Other theories [e.g. decelerating QSSC (Vishwakarma & Narlikar 2007); inhomogeneous Universe (Romano 2006); evolution of proton/electron mass (Thompson 2012)] can reproduce SNIa data.

Formation and evolution of structures and galaxies

3) Cosmological constant. Dark energy.

Doubts about $\Omega_\Lambda=0.7$ from other sources:

- CMBR anisotropies depend on many parameters and a model with $\Omega_\Lambda=0$ is compatible (Blanchard et al. 2003)

- $\Omega_\Lambda=0.7$ produce far more high redshift massive clusters than observed in all existing X-ray surveys (Blanchard 2006)

- Size evolution of ultracompact radio sources gives $\Omega_\Lambda<0$ (Jackson & Dodgson 1997)

- All tests before ~1995 gave $\Omega_\Lambda\sim0$

WHAT IS DARK ENERGY?

Formation and evolution of structures and galaxies

4) Distant galaxies. Evolution. Age of the Universe

- Among the few independent results, it is the chemical composition of the galaxies from the spectra. Result: galaxies at very high redshift ($z>6$, age<1 Gyr) have metal, dust abundances like the local galaxies. Very quick evolution?

- Age of the galaxies: no big problem now (if $\Omega_\Lambda=0.7$), although still there are some galaxies with average age of the stellar population around the age(z) of the Universe. Very quick evolution?

CONCLUSION

There is not a full consensus that the standard model of cosmology is well established and with clear interpretations of all the observations.

Reference:
López-Corredoira (2017), invited review in:
Foundations of Physics, special issue on Astrophysics and Cosmology

For a provisional versión: ask it at martinlc@iac.es