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Title

A fairly summary summary

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Author

Trimble, V

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A FAIRLY SUMMARY SUMMARY

Virginia Trimble

Astronomy Department
 University of Maryland
 College Park MD 20742

and

Physics Department
 University of California
 Irvine CA 92717

ABSTRACT: All of the expert and prestigious people who were invited to provide concluding remarks for the symposium found that they were going to be elsewhere this week. Faute de mieux, the (very considerably) senior editor provides a run-down of highlights of the oral presentations.

1. INTRODUCTION

It was originally intended that the three days of the meeting be focussed sequentially on clusters of galaxies, gravitational lensing, and determination of the cosmological parameters. In the event, nearly everybody spoke about at least two and sometimes all three of the topics, suggesting that the mix was not quite as odd as it originally sounded.

2. WE LIVE IN A LOGICAL UNIVERSE

And, therefore, when the mass and mass distribution of a cluster of galaxies are determined from more than one indicator the answer ought to be the same. Indicators include velocities of stars, globular clusters, and galaxies (Tsai), tidal effects (Gallagher), X-ray luminosities and temperatures (Mushotzky and others), and weak and strong gravitational lensing (Natarajan, Hewitt). At least crudely, you do get the same answer (Mushotzky, Bahcall). Deviations are virtually always in the sense of the lensing masses being the largest (Natarajan, Kaiser, on MS 1224, Abell 2218, Abell 1689).

It is perhaps less logic than innate perversity of inanimate objects that guarantees that whenever a cluster is dense enough to lens, it kills all its dwarf spheroidal galaxies, at least theoretically, and observationally in one case (Gallagher, who used $H = 75$).

The various speakers did not agree on values of the standard parameters. Many simulators of large scale structure took $H = 50$ km/sec/Mapc (the simulations tend not to come out very well with large H). Freedman reported 80 (± 6 , ± 15) from the HST Key Project. Tanvir arrived at 69 from Coma and the Leo I group and Narayan at 47-58 or 64-80 from time delay in a gravi-

tationally lensed QSO at RA = 0957.

The total density parameter, Ω , is at least as poorly determined as H . Peebles concluded that the observations suggest a value of 0.2 ± 0.1 , while Bahcall advocated $0.2 h^{-1}$ for the matter density, but a cosmological constant to bring the total up to unity. Many simulators simply assumed one.

3. EVOLUTION (PART I)

Everything changes. Among stellar populations, the old will get younger (because of mergers) and the young will get older (in the usual way), according to Wyse. Meanwhile, we will become extinct (Gott).

X-ray clusters do (anti)evolve, in the sense of there being fewer at moderate redshift. But some with very large L_x are turning up at $z = 0.5 - 0.8$ (Ebeling, Donahue). This is a bit reminiscent of quasars at redshifts larger than 2-3; not very many, but very bright. At least one $z = 0.5$ cluster has a baryonic (hot gas) mass fraction a good deal smaller than we find for many local clusters (Donahue). Shapes of the clusters apparently constitute an evolutionary sequence (Buote).

At these same moderate redshifts, the large scale structure traced by optical galaxies and their redshifts is not very different from here and now, at least in numbers and sizes of voids (de Lapparent).

4. THEY SAID IT WOULD NEVER FLY

A number of talks reported results from facilities and projects sufficiently complicated that critics had doubts of their feasibility up to and even beyond first light. These include the Keck segmented telescope (Cohen), the Hubble Space Telescope (Macchetto), MACHO and other microlensing searches (Bennett), FIRST (Helfand), and the Sloan Digital Sky Survey (Richmond; admittedly you are still allowed to doubt the ultimate success of this one, but I don't think it's a good bet).

On the other side of the fence, we must extend sympathy to N. Tyson (whose talk was presented by Richmond) and his quest for supernovae in the OGLE data base. The number found was zero, but, as Maurice Goldhaber said in another context (double beta decay), that's a lot for that experiment.

5. NEW LENSES AND TYPES

Shaya and Ratnatunga reported several new lensed quasars identified with HST. About one elliptical in 25 should be the lens for such a configuration. The mass implied for the lens

of one new object requires, however, a velocity dispersion in the galaxy of about 430 km/sec. The observed value is 220 km/sec.

Brainerd reported evidence for weak lensing (meaning you get arcs, not separate images) of galaxies by galaxies that imply gE masses of $1-2 \times 10^{12} M_{\odot}$. This should not be confused with strong galaxy-galaxy (or galaxy-quasar) lensing (where you see discrete images), with weak cluster lensing of background galaxies, or with strong cluster lensing of background galaxies and quasars.

The numbers of strong lenses found implies that the cosmological constant contributes less than half of what it takes to make space flat and also that the real density parameter must be at least 0.2 if the cosmological constant is zero, according to Hewitt. She also suggested that you need to study both weak and strong lensing by a cluster to do a good job of deconvolving to get its $M(r)$. Finally, she reported the first FIRST lens (found in a new radio all-sky survey).

Nemiroff regretted that he was unable to report any evidence for lensing of gamma ray bursts, since it would be important evidence concerning their distances from us.

6. MODELS OF STRUCTURE AND SUBSTRUCTURE

The Coma cluster has both a blue blob (Aldering) and some segregation of faint and bright galaxies around both of its X-ray peaks (Gerbal). Crone and Mohr both reported on simulations designed to use substructure in X-ray clusters as a probe of cosmological models (via the time available for evolution). They agreed that $\omega = 1$ is OK but disagreed about whether a smaller ω supplemented by a cosmological constant is also OK.

The standard cold dark matter model is at least terminally ill, if not dead. The real problem is best described not as "too much structure on small scales" or "not enough power on large scales" but simply as the wrong shape of the power spectrum. Several minor fiddles can, however, improve the fit to the real world considerably (Scott, Brainerd).

7. EVOLUTION (PART II - MERGERS)

The biggest surprise here (perhaps it shouldn't have been) is that mergers can yield a core radius for the X-ray gas that is larger than that of the dark matter, amounting in effect to anti-dissipation (Burns). They are also expected to make globular clusters because gas gets shock compressed. An example is the young, rich star clusters in the LMC, resulting from its interaction with the Milky Way (Whitmore).

The intracluster medium of X-ray clusters is very rich in oxygen, silicon, and iron, in proportions implying that a very

large number of type II supernovae have contributed, presumably again at least partly an effect of interactions. We do not obviously see primordial galaxies as bright as the SN hosts ought to be. Possible excuses include dust, star formation at a very high redshift, or star formation dragged out over a very long time (Loewenstein).

Intracluster gas distorts the shapes of what would otherwise be large double radio sources into ones with head-tail or wide angle tail morphologies. As a result, such sources locate rich clusters for you, even if the optical emission has not yet turned on or is hidden by dust, or whatever (Helfand).

8. ASSORTED CAUTIONS

Do not trust an observer at less than three sigma (Feldman on evidence for large scale streaming). Do not trust a theorist at less than three epsilon (Summers on simulations of large scale structure). And remember that redshift space underestimates clustering of bound entities ("finger of god effect"), but overestimates the clustering of infall regions (Geller).