# PANEL CONTRIBUTION–IAU SYMPOSIUM 168

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These brief comments will reflect the point of view of an observer, rather than a theorist. They will also be quite informal, as were the remarks I made while at the symposium in The Hague. Finally, I will restrict myself to relatively low energy proton backgrounds–roughly speaking from $10^{-5} - 10^{1}$eV. I fear that will slight the important work being done by our colleagues on the X-ray and gamma ray backgrounds, but those topics were nicely covered in the symposium itself.

The last IAU symposium to deal with questions of cosmic (and Galactic) backgrounds was held 5 years ago in Heidelberg. If I may use that earlier meeting as a benchmark, I am struck by how much progress we have made in the past 5 years, and, frankly, by how uneven that progress has been.

At the risk of seeming parochial by placing an area of my own interest at the top of the list, I would begin by pointing out one spectacular success: the determination of the spectrum of the cosmic microwave background radiation (CBR); see Mather *et al.* (1990), Gush *et al.* (1990) and Mather *et al.* (1994). As another contributor to this panel has noted, in many ways this precision measurement of the CBR spectrum is an even more crucial result than the long-awaited discovery of fluctuations in the intensity of the CBR. I do not wish to minimize the latter, however. Observers like myself have been seeking measurable fluctuations in the angular distribution of the CBR for more than a quarter century. With the exception of a few false alarms, and the robust detection of a dipole moment ascribed to the velocity of the earth, no variations in the angular distribution were detected until 1992 (Smoot *et al.*). That paper has unleashed a flood of additional reports of positive detections, many nicely reviewed by Lubin in this volume. I would say that the observational situation is at the moment a little uncertain on angular scales smaller than the 7° beam of the COBE-DMR instruments. As the dust settles (and workers in the field will realize this is a pun with some point), I suspect we will have found that we do have robust detections of CBR fluctuations on degree scales as well as the larger angular scale



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variations reported by the COBE team. These results, combined with the very tight limits on spectral distortions, I believe, will greatly enhance the astrophysical and cosmological utility of the CBR. In fact, the best studied of all cosmic backgrounds has become even better characterized, and has much more to contribute to astrophysics and cosmology.

Moving up a step in frequency, we seem to be tantalizingly close to reaping the great riches of far infrared background astronomy. That, at least, is the optimistic conclusion I draw from the fine review by Hauser in this volume. It is interesting to contrast the spectacular success of Mather and his team with the much tougher task faced by Hauser and his. Do remember that the graph of the CBR spectrum so many of us have seen so often was determined from *11 minutes'* worth of COBE data taken in late 1989. By contrast, Mike Hauser and his colleagues are still trying to sort out local foreground contributions in the far infrared, years after the COBE instrument that took the data has shut down. I'll come back to this point in a moment.

In the meantime, however, let me move to the optical. It is intriguing that the cosmological background in the optical, which was the subject of considerable discussion in Heidelberg 5 years ago, received essentially no attention here. Instead, interest focused on counts of galaxies made in the optical (or near infrared K band) and on questions of galaxy evolution. My non-expert reading of the field is that the counts of galaxies are now in good shape, and that the apparent disagreement between counts made in the B and K bands is no longer a cause for concern. On the other hand, as Koo among others noted here, the question of galaxy evolution is still far from settled. Simon White's talk made that clear; so, too, did Dave Koo's conservative, reductionist suggestion. It is intriguing that some 30 years after the paper by Eggen, Lynden-Bell and Sandage (1962) and the various models of galaxy formation that followed from it (eg. Partridge and Peebles, 1967), we still can't say whether we have detected bona fide primeval galaxies or not. The poster by Pritchett *et al.* here says no; the work by Miley and Chambers here and elsewhere says yes. I should go on to say that the problem with galaxy evolution is not just a problem with high redshift objects; there are plenty of open questions about galaxy evolution even at modest redshifts of order $0.5 - 1$.

Here it is appropriate to insert a word of praise for those doing redshift and other large-scale surveys in the optical. There has been spectacular progress on this front in the past 5 years and spectacular promise for the years to come. That some of us are talking about the possibility of a new IAU Commission on Large-Scale Structure is one reflection of the fine work by observers on these teams as well as those making more and more sophisticated computer models of large-scale structure and its evolution.

In my view, even more dramatic results have been derived from the use of gravitational lensing to allow us to see high redshift or faint background objects as well as to trace out the mass distribution in foreground sources. While most of that work has been done in the optical, radio astronomers are now beginning to make their contribution to the astrophysical and cosmological results from such studies, as well as to the location of lens candidates. Since gravitational lensing was beautifully reviewed in this symposium by Peter Schneider, I won't pursue the topic in detail, but I'd put substantial money down that gravitational lensing will be a more and more useful tool in cosmology over the next 5 years.

Before ascending further up the frequency ladder, I do want to point to the contributions made by radio astronomers in the characterization of moderate redshift galaxies as well as the discovery and characterization of gravitational lens sources. That work is nicely reviewed in a brief paper by Wall here. Radio astronomers have now pushed the counts down to nearly microJansky levels (Windhorst *et al.*, 1994), and are beginning to discover the sky is "paved" with radio sources in the same way it is with faint, $26^{m}$, optical Galaxies.

Finally, the situation in the UV strikes me, as a low-energy photon person, as still quite complex and even disputatious. Is there an overall cosmological background in the UV; and, if so, is it relatively bright or relatively faint? It seems to me that we do not have convincing and widely accepted answers to those questions. It is equally clear that we have very able and innovative observers working on the questions, as the reviews by Jakobsen and Bechtold indicate. My hunch is that we'll have a much clearer picture of the ultraviolet background by the next such IAU symposium .

Now for a few generic conclusions. The first of these is that many of the remaining problems in all of the fields I've touched on above involve rather ordinary, messy, astrophysical issues. I hasten to add that I am *not* saying that all the basic problems are solved and that we now find ourselves tidying up the loose ends. Quite the contrary; the large problems have *not* been solved, but I believe the solution may well involve grubbing about in the messy details.

The most salient example is sorting out the foreground contributions to the infrared sky brightness. In different wavelength bands of the infrared, one has scattered sunlight, reemission from interplanetary dust, Galactic emission, possible band and line emission from PAH's, and much else. As Hauser's talk suggested, the goal in sorting out these foregrounds is partly to understand them in their own right, and partly to pare them away so that we can get at the truly cosmological background (which itself may be complex). We will need much better characterizations of the interplanetary dust and of the dusty emission from our own Galaxy before we can get to the kernel of the cosmological issues.

Many other unsolved problems, I suspect, will involve the same kind of careful work. I've already alluded to some of the issues in the ultraviolet background, and there are plenty of other examples scattered throughout the talks at this symposium. Let me provide a quick and certainly incomplete list: indirect upper limits on the ultraviolet flux, the question of wide-spread dust in the Universe (as revealed, for instance, by the newly discovered "red quasars"), the evolution of galaxies at both high and moderate redshifts, the galaxy luminosity function at the faint end, and the contamination of the CBR by foreground sources.

The fact that there are so many problems remaining I would regard as both good news and bad news, if you'll allow me a rather sociological comment. The bad news, of course, is that in some fields the glory days are over. The next steps may be hard and unglamorous. Again, I wish to repeat that I am not saying that we've been reduced to straining for the last decimal place. Rather, I'm saying that in order to answer the big questions, we may have to do some rather conventional astronomical work.

The good news is essentially the same–that there *is* a lot of work yet to be done. Much of it involves relatively straightforward, if painstaking, astronomical observations, of the kind that all astronomers, not just those with multimillion dollar satellites or state-of-the-art telescopes, can engage in. We stand to learn a great deal, for instance, from further study of gravitational lens sources, from confirmation of reported detections of CBR fluctuations, from a deeper understanding of the role of dust at moderate redshifts, and from a more careful characterization of Galactic emissions at ultraviolet, radio, submillimeter and infrared wavelengths. Here lies the future of the field, in my view, and here lies my optimism.

## References

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Other papers referred to are in this volume.