OPEN DISCUSSION; SESSION IV (Chairman: Gösta Lyngå)

LYNGÅ: Let us begin this open discussion with a comment by Dr Veron.

VERON: This is comment to Dr Lequeux. In a recent preprint, Moorwood, Veron-Cetty et al. have shown that the galaxies in IRAS minor survey don't have an excessive infrared flux but rather low apparent B luminosity due to strong extinction which may vary from one to two magnitudes.

LEQUEUX: Yes, the important thing is the absolute value of the far infrared luminosity and it is usually very, very much higher than in normal galaxies. I think these are two sides of the same problem.

VERON: The infrared blue luminosity is not as high as the face value.

AUDOUZE: A question for Bernhard Pagel. Of course, I am delighted that he concludes that the primordial abundance of helium is lower than the one quoted by Kunth and Sargent, which was starting to make a little bit of a mess in the primordial abundances and then give a little bit more work for the theoreticians studying primordial nucleosynthesis. My question is the following: Kunth and Sargent claim that there is no evidence for a correlation between $\Delta Y/\Delta Z$, while yourself you quote a very large value. Could you say why you find such a difference between your results and their results?

PAGEL: I'm more accurate.

McCALL: A question to Dr Pagel. You mentioned that Terlevich used the equivalent width of Hβ emission from extragalactic HII regions to investigate variations in the initial mass function. Observations of Balmer absorption equivalent widths for the embedded OB associations indicate that the optical continuum is predominantly contributed by evolved stars. Was this taken into account in Terlevich's analysis?

PAGEL: Well, the expected continuum from the gas is taken into account, but this is very weak. As you know if you just had a pure continuum from the gas the equivalent width of Hβ would be enormous. What is suspected is that perhaps some of these stars are even in a pre-main-sequence stage, anyway stars of low gravity, which would account for the weakness of the Balmer line. So most of the continuum we still think comes from stars.

SCHILD: A comment to Dr Lequeux, please. If I might expand your

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discussion of possible causes of star burst, we have observed in the galaxy NGC 1068, which is of course a Seyfert galaxy with a very active jet seen in both the radio and the infrared, a coincidence between three sites of very active star formation and the alignment of that nuclear jet. So we have an inference, although no direct proof, that perhaps beaming of particles or electrons from the jet may have induced that star formation. I regret that it is difficult to draw a more conclusive connection.

LEQUEUX: No comment.

DAS GUPTA: Has anyone done the non-thermal radio observation of NGC 6240, since you say that the infrared luminosities are 1000 times the bolometric. What about the non-thermal radio emission from this galaxy?

LEQUEUX: The non-thermal radio emission is very strong. I take the opportunity to give another answer to Dr Veron. In fact, the infrared/blue luminosity ratio may not be a sufficient criterion for saying there is a star burst. It turns out that in most of the galaxies which have a very high infrared radiation compared to the visible, the dust is very hot and this is a certain sign of the presence of very massive stars. It is hotter than the average.

TORRES-PEIMBERT: I would like to insist that there is observational evidence of the enrichment in metal-rich HII regions; this points out to a helium enrichment proportional to heavy element enrichment. From the comparison of metal-poor irregular galaxies like SMC (Y=0.24, log O/H=7.9) and NGC 2363 (Y=0.23, log O/H=7.9) to metal-rich HII region like the Orion Nebula (Y=0.28, log O/H=8.6) and M17 (Y=0.30, log O/H=8.8). I suggest that the failure of different authors to find a $\Delta Y/\Delta Z$ value different from zero, stems from the sample of objects selected that do not have a large enough baseline in Z.

PAGEL: I agree.

LYNGÅ: Could I just ask André Maeder. Does you theory agree with the helium abundances as they were presented?

MAEDER: May I show a transparency?

LYNGÅ: We would like to see it.

MAEDER: $\Delta Y/\Delta Z$ ratio is closely connected to the initial mass for black-hole formation. Suppose that above 40 $M_{\odot}$, for example, you would have black-hole formation with all this matter here taken into the black hole. This would increase the $\Delta Y/\Delta Z$. If you remove this, you would have a higher $\Delta Y/\Delta Z$ ratio. So this ratio very much depends on the initial mass above which black holes are formed. Suppose that there is no matter locked into black holes. In this case, we would have $\Delta Y/\Delta Z$ ratio equal to 1. Now, the more mass you lock into black holes, the higher $\Delta Y/\Delta Z$ ratio, and a value like 3.5 as given by Dr Pagel would

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imply that most of this mass here, most of these heavy elements are locked into black holes. So my point is that there is a close connection between $\Delta Y/\Delta Z$ ratio and the amount of mass locked into black holes.

LEQUEUX: If this story is true, this will reduce the yield in oxygen, because the yield is essentially the amount of oxygen which is produced. There you need star formation.

PAGEL: May I just make a comment myself. As James said quite rightly, making black holes above a certain mass limit also has the desirable consequence of giving us a low yield in irregular galaxies. What worries me slightly is the picture that Silvia put up just now, which showed a precisely constant trend of $\Delta Y/\Delta Z$ going right up to Orion and further, where from the point of view of heavy element abundance the yield is presumably considerably higher than it is in the irregular galaxies and I don't quite see how to put those two clues together.

LEQUEUX: I think that strictly speaking, we should not compare Orion and M17 to irregular galaxies because their present chemical abundances are the result of a complicated galactical evolution, while after all irregular galaxies may well behave as closed-box systems, simple systems. Strictly speaking, it's hard to compare those systems which seem to be very different.

WILLNER: I have a question for Dr Lequeux. I'm fascinated by this suggestion that τ_d and τ_c will control the star formation history in the Galaxy, but I was confused by the last slide, which said that if the density is high τ_d would be much larger than τ_c. It seems to me it should be the other way around. So maybe you could say how these things vary with density and why?

LEQUEUX: I'm sorry I didn't catch everything you said.

WILLNER: Could you just say how τ_d and how τ_c vary with density. It seems to me τ_d is just a property of the molecular cloud. It should be independent of density, while τ_c should go down at high density. Your last slide had the opposite of that.

LEQUEUX: I'm afraid I cannot answer that. It's just a bright idea. The consequences have to be explored fully.

McCALL: To Dr Pagel: For highly ionized HII regions like those to which you restricted your helium abundance analyses, Shields has found that the diameter of the ionized helium Strömgren sphere exceeds that of the ionized hydrogen Strömgren sphere. Did you correct your helium abundances for this effect?

PAGEL: I know the work you are referring to. The models that I have seen are the Stasinska models and some of the calculations with Ferland's code. Although they do give you a bigger helium sphere than

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hydrogen sphere, the difference is generally of the order of 1% or less, so I have neglected it.

GALLAGHER: I have a question for Dr Pagel. In converting the metal scale of the elliptical galaxies to that of irregulars, did you offset between oxygen and iron abundances or is that just a straight, one of those magical, metals over hydrogen ratios?

PAGEL: That is just a magical metal over hydrogen ratio. You see there is a dilemma, which is that the supergiants in the SMC are not as deficient in metals as you might expect. This is also true of cepheids. It is a result that has been around for years. From the colours of cepheids in the SMC and also from high-dispersion abundance analysis of supergiants in the SMC, the [Fe/H] is only about -0.5, so it would probably be misleading to apply to the HII regions the ratio of [O/Fe] that you get from stars. What I did in practice was to neglect all these effects and just use a straight [Fe/H].

TORRES-PEIMBERT: What are the present thoughts on the problem that the star burst galaxies pose? They probably have large amounts of gas from which they are now forming stars very efficiently (and therefore they were not very efficient forming stars in the past) and the large amounts of dust that they show.

LEQUEUX: I just have an idea about this excess of dust. It may be that the light from the galaxy you see is entirely coming from these massive objects and seeing that the massive objects are formed preferentially in regions where there is a lot of gas and a lot of dust, the dust excess would be a normal consequence of that. Well, this has to be explored.

McCALL: Maybe I can clarify that slightly. You only need optical depth $\tau=1$ in the UV and if you have that, all the luminosity will come out in the far infrared and so you don't particularly need a large amount of dust, you need actually a very small amount of dust, what you need is a large luminosity at short wavelengths.

LEQUEUX: Of course, I agree, but the point that Dr Veron made was that these galaxies seem to have a high amount of extinction and I think this is all interrelated.

GALLAGHER: I disagree with that because if you just take an O star and absorb all of the energy out of the ultraviolet and still leave the optical flux, let's say with moderate optical depth, you get a value of only maybe 40-50. In order to get the very high values of L_R/L_B seen in galaxies like Arp 220, you must have substantial optical depths in the visible to reduce the blue luminosity power output, even for a massive star, hence the initial mass function.

LYNGÅ: Any other comments? Well, Ken Freeman, I wonder what we should have heard from all this? You can have almost thirty minutes if you want it.

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