# CONCLUSION

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This joint discussion has amply demonstrated that stellar atmospheres are not passive and dumb bodies just sitting there at the surface of a star.

First of all the surface "feel" fundamental parameters of the star as a whole, specifically the ratio $L/R^2$ and $\mathcal{M}/R^2$. As these fundamental parameters are affected by stellar evolution, the surface layers reflect to a large extent the degree of evolution of the star. This is the main basis for photometric and spectral classification systems. One could even claim that the observation of the stellar atmosphere would univocally determine the state of evolution of the star if i) it was always possible to determine the atmospheric abundances of the key elements to internal structure and ii) if the chemical composition of the atmosphere was always representative of the chemical composition of the whole star. Unfortunately a serious problem occurs for i) with the abundance of helium which element has no photospheric absorption line for all spectral types later than B and also with ii) in a more limited portion of the HR diagram, mainly in late B and A slow rotators. But whereas point i) is a mere problem of contingency, point ii) is a basic problem, greatly overlooked in the past, and to which one fourth of the joint discussion was devoted.

The most elementary type of motions, very clearly described in Dr Michaud's paper, arises from the fact that the individual particles are driven by forces depending upon their mass, charge and radiative cross section, personal to each species, resulting in a trend for each species to stratify with its own scale height. This type of motion, currently known as diffusion, has the capital effect of destroying the initial chemical composition of the atmosphere, well mixed with the envelope during the Hayashi phase of stellar contraction. If these diffusion motions are not counteracted by other types of motions, then the chemical composition of the atmosphere is expected to evolve with time, with a "diffusion" time scale. That is now believed to be the correct explanation of several peculiarities occuring in late B and A stars.

However, most of the time, these diffusive processes are disturbed

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by several types of macroscopic motions. One is the existence in stellar atmospheres of random motions due to convective instability ( or other instabilities ) occuring almost everywhere in the HR diagram. These random motions tend to destroy the diffusive separation of the elements but do not prevent selective losses of elements at the boundaries of a more or less homogeneous " reservoir" well mixed by random motions. Then come some organized motions as mass loss and meridional circulation. If meridional circulation is still poorly known, great progress has been made in the empirical knowledge ( thanks to observations from space ) and understanding of mass loss. It turns out that high luminosity stars have mass loss rates such that the matter in the atmosphere is turned over in a characteristic time of a minute or so. Such a rate of mass loss is large enough to alter the mass of the star within the nuclear time scale and then needs to be taken into account in the computation of evolutionary tracks.

Elsewhere in the HR diagram mass loss rates seem to be several orders of magnitude smaller but are still existing and may be significant when one is concerned with diffusion processes and loss of angular momentum.

Stellar atmospheres are indeed a very complex kind of upper boundary condition for internal structure, due to the fact that the decrease in density by ten orders of magnitudes occuring in the atmosphere-chromosphere-corona regions leads to supersonic flows, extremely high temperatures, and mass loss.

Perhaps simpler in principle, but not yet satisfactorily accounted for by the theory, is the chemical composition alteration of the surface layers which could be caused by mixing of burned products in the core with more superficial layers. This still remains an extremely attractive subject of study, as a way of having direct evidence of nuclear events which are occurred in the interior of the star. The best chance of explaining a mixing of this sort seems to be the saw-tooth alternance occuring on the asymptotic branch, the bottom of the convective zone being possibly able to reach at times regions where nuclear activity has taken place before.

More advanced is the interpretation of the abundances of the light elements Li, Be ,B in stellar atmospheres. There is little doubt that these elements are destroyed in stars having a deep convective zone.

The fine interpretation of the abundances of these elements establishes a direct connection between observables at the surface of the star and things happening deep below at temperatures of millions of degrees.

Summarizing, this joint discussion has made clear how stellar atmospheres can be used not as an object of study per se , but in order to achieve a more complete understanding of the star as a whole and of its evolution.

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