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Report by supervisor on Ph.D.- thesis of Mr. David Bahena Bustos

"Physics of Hot Luminous Stars
– Structure, Evolution and Nucleosythesis of the First Stars"
(Fyzika horkých svítivých hvězd
– Stavba, vývoj a nukleosyntéza prvních hvězd)

Mr. David Bahena Bustos entered the PhD studies at Charles University in Prague in a more advanced age than it is usual. He had already great experience in scientific work from his native Mexico. He had also his own ideas how to continue. The main goal of his study was to renew and enlarge his knowledge of relevant parts of astrophysics and to use the time for a devoted work in the subject. Some difficulty was also with improving his English, but he succeeded in this respect as well. His work can be characterized first of all as a thorough one. He dealt with all steps of the study in details, sometimes even overabundant. For instance, for the examinations on subjects like stellar atmospheres he compiled his own textbooks. He prefered to devote himself completely to a single problem at a time, so he started to work intensively on his thesis only after finishing the examinations. The review part of the thesis also illustrates his effort for completeness. His thesis, in spite of its large extension, is in fact a selection only from preliminary versions, which tackled also wider cosmological contexts. This approach caused some delay in his study, but he can profit from it in future equally as from many numerical results achieved, which should be published in future.

Mr. Bahena developed the idea to apply his previous experience in modeling the stellar evolution on the problem of supermassive first stars. This topic gains a broader attention during last years. It is interesting from the methodological point of view because it reveals the role of initial chemical composition on the stellar evolution as well as the properties of very massive stars and possible limitations on their existence. However, even more important are the consequences, which contribute to the understanding of several problems of contemporary cosmology – first of all the chemical evolution of the universe or its reionization. Recent progress in observational cosmology strengthens the need of more precise quantitative results of theoretical studies like those contained in the thesis submitted by Mr. Bahena.

For a more concrete summary of results achieved by Mr. Bahena, I would like to quote the following part from recent letter by Dr. Jaime Klapp, who is advisor of Mr. Bahena and who is closely involved in technical details of the work:
– *I constructed the original code in the late 70 but I stopped working on stellar evolution in the mid 80's, moving to stellar pulsation and later to star formation. I gave the code to Mr. Bahena some years ago but the code required major changes.*

– The major improvements and modifications he did to the code were:
i) He updated the physics, mostly some nuclear reaction cross sections and the opacity.
ii) For solving various problems and improving the convective, semiconvective and overshooting treatment usually incorporated in stellar evolution codes for massive star calculations, he implemented the treatment of composition mixing through a true diffusion equation. This approach gives a better and more realistic representation of massive star evolution. I estimate that during the next year he will write a paper dedicated specifically to discuss the new approach. Some of these results can be found in his thesis, but many were omitted in his already too long thesis. ...
– He made a large number of massive and very massive star calculations with different masses, compositions and mass loss rates. He is already writing a new paper for A&A.
– The results presented in the thesis are consistent with those obtained by other authors for different masses and compositions and reveal important properties of the first stars. There are several interesting results regarding nucleosynthesis and mass loss of pregalactic VMS and the role of these stars in the reionization and initial enrichment of the universe.
– An interesting result is that mass losing VMS can reach the WR region with a very different evolutionary track than usually assumed for massive star evolution.
– Another important contribution of the thesis is related to the role that very massive stars may play in the cosmological scenario. In the recent literature advocates of very massive stars assume the first generation of stars are born very massive and evolves without loss until their final collapse to black holes. However, as described in the thesis, this scenario is in conflict with observations and several authors have suggested that the first stars are normal massive stars. In the thesis an original and interesting scenario is proposed where the first stars are born very massive but through mass loss evolve into normal massive stars by the end of their helium burning phase. The scenario proposed in the thesis is consistent with observations and it "saves" the VMS first stars hypothesis. Nobody in the literature has made this suggestion.
– All recent VMS calculations assume evolution with no mass loss. In the thesis strong arguments are given why this assumption is wrong and that the possibility that first stars VMS have strong mass loss is still open. This is really a proposal for future work but justifies the use of mass loss. ...

In my view, this list shows well the results achieved by Mr. David Bahena Bustos in his thesis. The thesis satisfies all requirements put on Ph.D.- thesis. It clearly proves the ability of the candidate for scientific work. I thus recommend to reward Mr. Bahena Bustos after presentation of his thesis by the degree "Doctor of Philosophy" (PhD).

In Prague 4. 5. 2006