Summary of Research

National Aeronautics and Space Administration
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Model Atmospheres and Spectra for Extrasolar Giant Planets

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Abstract

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In the past few years much new observational data has become available for brown dwarfs and extra solar planets. Not only are new objects being discovered but the availability of higher resolution spectra is improving. This allows a better comparison between the models and the available data, and places new constraints on the models which now have to be made more physically realistic in order to better interpret the observations. Under this grant, an array of new opacities were calculated and successfully applied to a variety of physical situations that were used as input to model available observations of brown dwarfs and extra solar giant planets.

Accomplishments

A series of programs has been developed to compute molecular opacities for conditions relevant to brown dwarf/giant planet atmospheres. The input molecular databases are processed to produce both line by line opacities and correlated K coefficients which are then used as input to a series of modeling programs that produce physically realistic non-grey models for brown dwarfs and extra solar giant planets.

The generation of new opacities involved collaborations with other researchers who were studying opacities that contained hot bands - i.e. bands that arise from energy levels well above the ground state that only become populated at elevated temperatures. Using the new opacities of water, methane, and carbon monoxide plus other available data we were able to better model the spectra of brown dwarfs and to investigate various strategies for observing extra solar giant plants and their properties. The groups creating models then collaborated with several observers to get the best possible observational material in order to compare our models with observations.

The line profile program can account for either a Voigt or Lorentz line shape and includes additional data on the line shape in the wings when this data is available. The molecular opacities also incorporated the best available material on line broadening and line widths, including the fact that the main broadening agents in these atmospheres are molecular hydrogen and helium rather than the gases normally found in the earth's atmosphere.

For the studies performed under this grant, we used the technique of transforming the line by line opacities into K coefficients which used statistical averaging techniques to represent the opacity over selected wavelength intervals. This technique has proven useful in modeling the atmospheres of these objects although we are beginning to move to a different sampling technique in the more recent models. The development of these new methods was begun under this grant, although this work is still ongoing and not yet completed.

The results of these studies have contributed to improvements in our understanding of the atmospheres and structure of these objects.

Presentations and Publications

A Preliminary Ab-Initio Calculation Of The Spectrum Of CH_4 And Its Applications To The Spectra Of Giant Planets And Brown Dwarfs. Freedman, R. S.; Schwenke, D. W. American Astronomical Society, DPS meeting #32, Late Abstracts, #65.36, 2000.

Molecular Abundances in the Atmosphere of the T Dwarf GL 229B. Saumon, D.; Geballe, T. R.; Leggett, S. K.; Marley, M. S.; Freedman, R. S.; Lodders, K.; Fegley, B., Jr.; Sengupta, S. K. *The Astrophysical Journal* **541**, 374-389, 2000.

A Radiative Equilibrium Model of 51 Peg b. Goukenleuque, Cédric; Bézard, Bruno; Joguet, Benoit; Lellouch, Emmanuel; Freedman, Richard. *Icarus* **143**, 308-323, 2000.

Appendix

Subject Inventions Certification

There were no subject inventions required to be disclosed to NASA which resulted from this work. There were no subcontracts awarded under this Grant.