Variable Star Research Projects for Outstanding Senior High School Students

John R. Percy
Erindale College and Department of Astronomy, University of Toronto, Mississauga, Ontario L5L 1C6, Canada

Abstract Several variable star research and education projects have been carried out by outstanding senior high school students, as part of the University of Toronto Mentorship Program. These benefit the students, their schools, the mentor (me), my university, and the astronomical community worldwide.

1. Variable stars in science education

Variable star measurements are inherently simple, but their analysis and interpretation involve a wide range of scientific and mathematical skills—some of which would be understood by a junior high school student, and some of which would challenge an expert in the field. Thus, the use of variable star observation and data in science, math, and computing courses and projects can develop and integrate a wide range of scientific skills *at many levels*. Students can do real science, using real research data (with real errors), either from an archive, or from their own observations, and perhaps even advance our understanding of variable stars.

The AAVSO's education project *Hands-On Astrophysics* (http://hoa.aavso.org) enables thousands of students to do real science with real variable star data. For a decade, I have been taking another approach to using variable stars in science and math education, through the University of Toronto Mentorship Program (Percy 1990).

2. The University of Toronto Mentorship Program

The University of Toronto Mentorship Program enables outstanding senior high school students to work on research or education projects with faculty members. The Program is coordinated by the Manager of Liaison, Faculty of Arts and Science, University of Toronto. Mentors are recruited from a variety of departments in the university in May. A program handbook, including a list of projects and application forms, is sent to all high schools in and around Toronto at the beginning of September. Applications are received by the university at the beginning of October. Mentors choose a "short list" of applicants, and interview them in October. Successful students begin their projects in early November, and complete them in time for a poster paper session and reception in May. This event is attended by students, mentors, parents, teachers, and other interested people. Students are not paid for participation in the program, but they may receive a high school cooperative education credit for their work, or they may count their project as an "independent-study unit" in one of their senior high school courses. Some of my best mentorship students have continued working with me during the summer as paid assistants.

I should emphasize that the students in this program are among the best in the city. Their research skills equal (and occasionally exceed) those of the average university student. One student—Todd Veldhuizen—carried out a pioneering study of "chaos" in RV Tauri stars, many years ago.

What are the benefits of the Mentorship Program? To the student, it provides intellectual stimulation; research concepts, skills, and experience; a contact person and mentor in the university; and sometimes formal credit. To the mentor, it provides intellectual stimulation through contact with bright, enthusiastic students; useful research or educational work done; and personal and departmental links with the schools. To the university, it provides links with the schools; and an opportunity to recruit the best students. To the schools, it provides both personal and institutional links with the university; and help with the education process. I am very active in school liaison in my area, and, like other effective liaison programs, the Mentorship Program has provided many useful and enjoyable links with teachers and schools.

3. Specific projects

Almost all of the projects have been published in some form or another. They involve the following kinds of activities, all of which have proven to be appropriate and useful: processing raw data into a usable form; plotting and interpreting graphs; generating (O–C) diagrams to study period changes in stars, and fitting straight lines or parabolas to them; and power spectrum analysis using Fourier or self-correlation techniques. The students have also proven to be very adept at thinking about how variable stars might be applicable to their science and math courses. Several have given presentations to their classes, and some have even given presentations to teachers, and to astronomers. Several (including two mentioned below) have contributed to astronomy education projects.

I will end with a few recent highlights. Adrien Desjardins and Lawrence Yu analyzed a decade of AAVSO photoelectric photometry of two dozen pulsating red giants, using two different techniques (Percy *et al.* 1996). Margarita Marinova applied her high school math skills to the discovery of the first known example of a red giant (W Boo) pulsating in two modes simultaneously (Percy *et al.* 1997). Monica Milanowski wrote an interactive computer-based tutorial for *Hands-On Astrophysics*. Laura Syczak produced a time series of 35mm slides of RT Aur on eight consecutive nights, for use in *Hands-On Astrophysics* (Percy *et al.* 2006c, this volume).

4. Addendum, 2006

Since 1997, I have continued to supervise one or two mentorship students each year. Examples of their publications are Percy *et al.* 1999, Percy and Kolin 2000, and Percy and Hoss 2000, which are in the *Journal of the AAVSO* and therefore available on-line on the AAVSO website; and, more recently, Percy *et al.* (2006a, 2006b) in the *Publications of the Astronomical Society of the Pacific*. The first of these is the basis for the AAVSO's Autumn 2006 *Variable Star of the Season*.

I have also introduced a bit of structure to both my mentorship and undergraduate student research projects, by providing the following template for the students' project (and in the case of the undergraduate students, their report):

- Background reading (print and Internet) on stars, evolution of stars, variable stars, especially the kind that they will be studying in their project.

- Development and understanding of the objectives and strategies for carrying out the project, and knowing how this fits with what is known and not known about their topic. In other words: why are they doing this project?

- Description of the data that they are using: where they come from, what their accuracy is, how they are distributed in time, other important and relevant properties of the data.

- Description of the method(s) of analysis which they will use, including the algorithms and software. This may include Fourier analysis, self-correlation analysis, wavelet analysis, or (O-C) analysis. Understanding of the principles, strengths, weaknesses, peculiarities, and other special properties of the method, algorithm, and software.

- Testing the software with data in which the likely results are known. Ensuring that they understand, and can explain the output of the software.

- Analysis and interpretation of the data on "their" stars. This is the heart of the project.

- For the Research Fair poster session: researching the principles of effective communication of science to a *general* audience, since very few of the participants in the Research Fair will know anything about astronomy. Preparing a poster on the project, which takes into account these principles.

- Preparing a final project report which will be the basis for writing a paper for publication in a research journal.

5. Acknowledgements

I thank the AAVSO observers and headquarters staff for providing the data on which many of my students' projects were based.

References

Percy, J. R. 1990, *J. Roy. Astron. Soc. Canada*, **84**, 49.

Percy, J. R., Desjardins, A., Marinova, M. M., Beresky, T., Luedeke, K., Smith, M. S., Thompson, R. R., and Wood, J. E. 1997, *Inf. Bull. Var. Stars*, No. 4467, 1.

Percy, J. R., Desjardins, A., Yu, L., and Landis, H. J. 1996, *Publ. Astron. Soc. Pacific*, **108**, 139.

Percy, J. R., Gryc, W., Wong, J. and Herbst, W. 2006b, *Publ. Astron. Soc. Pacific*, **118**, 1390.

Percy, J. R., and Hoss, J. X. 2000, *J. Amer. Assoc. Var. Star Obs.*, **29**, 14.

Percy, J. R., and Kolin, D. L. 2000, *J. Amer. Assoc. Var. Star Obs.*, **28**, 1.

Percy, J. R., and Marinova, M. M. 1999, *J. Amer. Assoc. Var. Star Obs.*, **27**, 122.

Percy, J. R., Molak, A., Lund, H., Overbeek, D., Wehlau, A. F., and Williams, P. F. 2006a, *Publ. Astron. Soc. Pacific*, **118**, 805.

Percy, J. R. Syczak, L., Mattei, J. A., Chumack, J., and Saladyga, M. 2006c, *J. Amer. Assoc. Var. Star Obs.*, **35**, 281.