Charts and Comparison Stars: A Road Map to the Future

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Abstract In the past few years the AAVSO's publication of variable star charts has undergone many changes. The result of these changes has been the creation of the Chart Team and the Comparison Star Database Working Group. We will describe these two projects and present early results. Then we will detail the future merging of these two projects into the Automated Chart Plotter (ACP), an online tool for observers to create star charts customized for their own equipment, observing location, and personal preferences.

1. Background

Creating variable star charts has always been a responsibility critically important to the mission of the AAVSO. If observers use different comparison stars when making an observation of the same star, combining their observations can be difficult and sometimes impossible. It is the length and homogeneity of the AAVSO International Database that makes it such a unique database in astronomy.

A history of the chart making process at the AAVSO is another paper in its own right. *[Ed. note: such a paper is in the works.]* The rapid pace of development of consumer equipment and online databases has turned chart making into a demanding and time consuming endeavor. High quality equipment requires high quality charts with precision unheard of only a couple of decades ago. The expanding observer pool also requires ever more objects to observe. It is now very clear that a manual chart creation process would never meet the needs of the observers. As a result, in 2003 the AAVSO reorganized its chart making program to take it into the future.

The new chart making program has a single focus: the creation of a program that will create online, customized charts automatically, thereby minimizing the amount of "grunt work" on which the chart makers spend time. The program is known in development as the Automated Chart Plotter (ACP). The ACP requires a database of all the comparison and variable stars currently labelled on AAVSO charts. From this database it can plot a field of the sky and accurately label all the variables and comparison stars within that field. In January 2003 the Comparison Star Database

Working Group was established to create such a database. However, the project will take a considerable amount of time (estimated completion date is summer 2005). Until then new charts needed to be made and older charts revised with better fields and more precise photometry. That is the responsibility of the AAVSO Chart Team, which began work in May 2003.

Together the two teams are working towards the creation of the ACP. The Chart Team is making new charts and the Comparison Star Database Working Group is documenting the existing charts.

2. The Comparison Star Database Working Group

The Comparison Star Database Working Group (CSDWG) is a dedicated team of individuals who are spending their free time documenting all the comparison stars and variable stars that exist on the current list of AAVSO charts. The database will be part of the automated chart plotter that the AAVSO hopes to build in the near future.

The existing charts are a paper-based system that dates back nearly 100 years. In the modern age of computers and the Internet, electronic data and access to that data is becoming more useful for amateur and professional astronomers. The Comparison Star Database Working Group is moving ahead to document the AAVSO's paper charts in hopes of using computers to better streamline and automate the chart making process.

The project was broken down into three phases to make this mountainous task more manageable. The first phase is to document all the labels and chart information into a database. The second phase is to add in photometric information, and the third phase is to reconcile duplicate information and work towards an electronic star-based system rather than a chart-based system. The estimated time of completion for phase one is summer 2005. At that point, the database will include over 65,000 records for the 3,800+ standard charts in the AAVSO chart repository.

While documenting the existing charts, the CSDWG has uncovered many discrepancies in both variable star positions and in wrongly plotted or non-existent comparison stars. There has been much collaboration with professional astronomers to resolve some of these issues and to verify the identity of some of the variables. The team is dedicated to providing accurate positions for all the variables and comparison stars. Certain professional catalogue numbers are also being included for cross-reference.

In addition to documenting the current charts, the Comparison Star Database Working Group is documenting all the newly released charts within a 30-day window and reporting any errors they find to the Chart Team. This process is running smoothly and provides another level of error-checking before the charts are released to the general public.

Because there is no database in the world that contains this kind of data, there is nothing to build upon. Documenting all of the AAVSO charts is very labor intensive and, because of the sheer number of charts, *more volunteers are always welcome!* Once built, this database will not only have a large impact on work within the AAVSO, it will also be a valuable resource for the variable star community throughout the world.

The 20 members of the Comparison Star Database Working Group come from all over the world to move this project forward into completion.

3. The Chart Team

The first step in creating new sequences and revising existing sequences was to establish a set of guidelines for the selection of comparison star sequences. Over a period of two years (2000–2002) the International Chart Working Group (ICWG), through meetings and discussions, established just such a set of guidelines.

The ICWG is comprised of people involved in chart making for variable star organizations including AAVSO, BAAVSS, RASNZ, and VSNET. It is a goal of this group that these guidelines would be accepted world-wide, which would lead to greater homogeneity in variable star observation databases around the globe.

The guidelines established in 2002 are as outlined below. It is important to emphasize that these are guidelines, not absolute rules. Each sequence is considered on a case-by-case basis.

1. Only use photometry that is accurate to at least ±0.05 magnitude. A magnitude error limit of ±0.05 is the standard for a visual chart; ±0.02 the standard for a CCD chart.

2. CCD charts should be linked to the complete sequence information via the web.

3. Only use comparison stars of known color ($B-V$, or its equivalent in the sequence color index).

4. Choose comparison stars that range between $0.3 < B-V < 1.0$ (or its equivalent in the sequence color index), with a conscious effort to select stars near ~0.7.

5. Steps between comparison stars should be between 0.3 and 0.5 throughout the range of the variable.

6. No redundant values.

7. Exclude close doubles as comparison stars.

8. Identify close companions to the variable as comparison stars (if possible), to aid in identification.

9. Choose comparison stars as close to the variable as possible. As a general rule, the fainter the comparison star the closer to the variable.

10. Avoid large spatial distances between comparison stars in the same magnitude range.

11. For visual charts, take position angle effect into account. Endeavor to pick comparison stars along a line running E and W of the variable if there is a choice.

12. Tycho-2 data can be used to 10.5*V*. However, each star must be weighed on its own merits for errors.

13. Since the original guidelines were established, we have also agreed in principle to accept *V* magnitudes from ASAS-3 as reliable from 8th to 13th magnitude, assessing the errors and limitations of this dataset on a case-by-case basis.

When revising existing sequences, there are additional guidelines.

1. Use as many of the comparison stars from previous versions of the sequence as are appropriate.

2. Eliminate redundancies.

3. Eliminate red stars.

4. Eliminate variables.

5. Eliminate close doubles.

In May 2003, a team of volunteers was assembled to revise existing AAVSO charts and sequences, and to create charts for objects not in the AAVSO observing program, as well as create charts for newly discovered objects such as novae and supernovae, in a timely fashion, to accompany *AAVSO Alert Notices*.

The ICWG sequence selection guidelines have been incorporated into the criteria for the creation of new charts and the revision of existing sequences.

Our initial goals and progress to date are as follows.

1. Set up the team and task assignments, and train volunteers to help in drawing and checking new charts. This has been accomplished—team members have exceeded our expectations and have been a pleasure to work with.

2. Release the backlog of charts for which draft copies had been made but had not been checked, corrected, and published. This task is completed.

3. Use all of the available reliable photometry we could obtain through literature searches and access to Arne Henden's photometry files to start revising and making new charts. Out of Henden's list of 280 cataclysmic variable fields planned for charting, nearly all should be completed and published as charts by the end of 2004. Dozens of Mira fields have also been addressed with photometry from Arne Henden, Ron Zissell, and the new AAVSO Calibration Team.

4. Establish a team of CCD observers to contribute additional photometry. The AAVSO Calibration Team has supplied photometry for the five initial target

fields requested—charts for all five should be published by September 2004. *[Ed. note: all were published by December 2004.]* We are currently evaluating the literature for other target fields for this group to calibrate.

5. Begin making cosmetic improvements to the worst looking charts, even if we couldn't revise the sequences due to a lack of reliable photometry for the fields. New cosmetically improved charts have been released for the constellations Boo, Cnc, CrB, Del, Leo, Peg, and Vir.

6. Organize and evaluate the errors reported to the AAVSO website, and begin to address them aggressively. The development of the Chart Error Tracking Tool (CHET) and the other web based tools for the chart team by Chris Watson has been enormously helpful. It provides a way to organize and prioritize the addressing of hundreds of errors reported to the AAVSO regarding comparison sequences and charts. This information also helps us to prioritize field calibration requests to Arne Henden, Ron Zissell, and the AAVSO Calibration Team.

In all, the AAVSO Chart Team has published over 1,000 charts in the first year of operation at a very low cost to the organization. Along with the continuation of our initial program, we hope to begin training more volunteers in the actual selection of comparison star sequences from large photometric datasets such as Arne Henden's field calibrations and the Tycho 2 and ASAS-3 photometric data.

4. The Automated Chart Plotter

The Automated Chart Plotter (ACP) is the final goal of these two projects. An observer will be able to build a chart from scratch to match their observing needs. For example, options for resolution, field of view, orientation, limiting magnitude, and aggregate data (such as CCD photometry, GCVS information, etc.) will be available. Calculators will allow the observer to optionally put in their telescope size and type, eyepiece size and type, and observing location to have all those options automatically calculated. In addition, predefined charts will be available for those who are in a hurry and just need to print a chart quickly. The software will also "remember" your past settings when you return. The program will be available via the AAVSO web site but printed charts will still be available for those without Internet access.

The ACP will be written in IDL under Linux. Currently AAVSO Headquarters has an IDL for Windows program created by former AAVSO Staff Astronomer George Hawkins to create chart templates. This program will be ported to IDL on Linux and expanded, and a web interface will be written in Perl.

Once the ACP is completed, the Chart Team and the Comparison Star Database Working Group will unite into one team. The role of the new team will be to choose suitable comparison stars and sequences for all the variables for which we do not currently have charts. This will *vastly* decrease the turnaround time for adding new stars to the AAVSO observing program and ACP.

5. Caveats and volunteers

The ACP is a work in progress. The features noted here are our current goals. The final product may vary a bit as testing and both technical limitations and innovations impact our work. Also, it has been well illustrated that these projects are only possible due to the devoted (and almost courageous!) tenacity of the volunteers. More volunteers are needed for both teams and for development of the ACP. Contact one of the authors if interested.

6. Summary

AAVSO charts are made for a reason: to help observers make high quality, consistent observations of variable stars. To succeed in this goal the charts have to be readily available and of high quality. At the same time, the AAVSO is a non-profit organization with limited resources. The Comparison Star Database Working Group and the Chart Team are working together to reconcile this dilemma. With their hard work a streamlined and accurate chart making system will be available in the near future.

7. Acknowledgements

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