Flare Star Research—A New Field of Astronomy for Photometrists Observing With CCD Cameras

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Abstract Flare stars and CCD photometry of flare stars is discussed.

1. Stellar flares and flare stars

The most prominent phenomena of stellar activity are short-lived flare events which occur in the atmosphere of K and M dwarfs and subgiants. *A stellar flare is the sudden and unpredictable enhancement of continuum and line fluxes* in the optical and UV spectral domains, and of X-ray and radio emission fluxes, which may occur *on time-scales as short as a few hundredths of a second*.

Flare stars (FSs) are red and cool with very low luminosity. Their spectra may contain emission lines and often belong to the dMe subclass. Since their absolute visual magnitude falls between $+8^{M}$ and $+15^{M}$, only those in the solar vicinity can be observed with medium-sized telescopes. As FSs flare up randomly, their discovery requires a lot of observing time. Even nowadays, with many hundreds of FSs catalogued, there are only a dozen known which flare up frequently enough to present themselves as suitable targets for single-object photoelectric photometers. Fortunately, Haro and Morgan (1953) discovered that FSs seem to cluster. Objects similar to the prototype, UV Ceti, were identified in the field of the Orion nebula. Since this young system, to which the majority of these variables may belong (Haro 1976) (as well as other relevant clusters), is so far from the solar system that single-object photoelectric photometry of its red dwarfs would be wasteful, photographic methods and Schmidt cameras are used instead. This way FSs in a field of about 20 square degrees can be detected simultaneously. Photographic photometry based on such plates allows a time-resolution of 4 to 10 minutes while unveiling only the larger-amplitude flares. Making use of this method, FSs have been discovered in the fields of many star clusters (e.g., NGC 2264, NGC 7000, Coma Berenices, Hyades, Pleiades, Praesepe; for details, see Szécsényi-Nagy 1990 and references therein).

2. Some questions to answer

Over a thousand FSs have been identified in the above-named fields, although positive identification could be proven only in the case of some brighter objects. For example, in the field of the Pleiades, not more than 35% of the FSs discovered had membership probabilities determined previously; this does not contradict the assumption that the majority of the FSs found there were cluster members. We tried to confirm this conclusion and our result was more than interesting. According to the recently-determined proper motions of these stars, hardly more than 50% of the reported FSs proved to be Pleiades members! (Szécsényi-Nagy *et al.* 1998).

Now, are there really so many field FSs in the fore- and background of that nearby cluster? To get a reliable answer we need a *l*arge amount of high precision photometric data, too (just for comparison, the photographic material for the Pleiades' field was secured during more than 3,100 hours of observing time). Consequently, this project could give work to a whole group of amateur photometrists for some years to come. Another question refers to the changing activity level of FSs. It has been found that the younger the cluster to which the FS is expected to belong, the higher its activity level. With that in mind, we can try to check the validity of this hypothesis by comparing the activity level of member and non-member FSs in the same field. Photometric patrolling of the field containing, for example, the Pleiades could contribute considerably to the understanding of the flare phenomenon and the evolutionary processes of FSs—and probably that of all red dwarfs as well.

3. What to do in the CCD era—a proposal

Why do I think that amateurs can now be involved in FS-photometry? Because they may have almost unlimited telescope time, short focal-length optical systems (i.e., a larger field of view) and more and more sophisticated devices, photon-detectors, computers, and software. Up-to-date 2*D* detectors (particularly CCDs) outrun photomultiplier tubes in quantum efficiency and ease of use and out-perform astrophotography in all imaging capabilities but their size. I believe that electronic imagers will replace observers' eyes and many other detectors soon. Since our target stars are definitely red, silicon, with its peak of sensitivity between 600 and 750 nm, is an ideal raw material for studying such stars' electromagnetic radiation. The photometry of FSs is a job which can be undertaken successfully even under slowly-varying skies because they outburst very quickly and the amplitude usually exceeds the photometric errors caused by atmospheric changes during such a short time.

Do you or your group own a Schmidt or a Maksutov camera (or an SCT) equipped with a fairly large CCD? Try to record a few flares! If the photometric error of your system is kept under 0.1 to 0.2 magnitude and you are able to reach the brightness limit of $B = 16$ in a minute, with reasonably short dead time between exposures, why not try to succeed in this branch of modern astronomy? Discovering field FSs in regions where no star clusters or associations are known would be a great achievement!

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