OPTICAL AND H-ALPHA EMISSION FROM UNRESOLVED RED DWARF STARS IN THE GALAXY

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1. INTRODUCTION

Although many of the nearest dim and cool stars (the red dwarfs) were catalogued in the early sixties, the majority of the astronomers did not realize that these objects provide almost nine tenths of all the stars in our Galaxy. In fact 90–95% of the stars in the solar vicinity ($r \leq 25$ pc) are main sequence stars, and at least 80% of them are M dwarfs. Outside the main sequence (MS) one can find a few subdwarfs and somewhat more white dwarfs, but the contribution of this latter type is not known precisely. Estimates range between 4% and 8%. The relative frequency of giants and supergiants can not be determined from the census of the local star population because they are not represented in a statistically meaningful number. But investigations of much greater cosmic volumes demonstrate that luminosity classes Ia, Ib, II, III, and IV altogether contribute fewer than 1% of the stellar content of the Galaxy.

Recent editions of the General Catalogue of Variable Stars contain more and more UV Ceti type (flare) stars and many of us are convinced that practically all of the low mass MS-dwarfs are (at least during a substantially long era of their life) non-stable objects and show flareups. These chromospherically active stars are often brighter than their temporarily quiet counterparts of the same spectral classes. During flareups they brighten up 1 to 7 magnitudes and depending on the spectral band and the duration of the phenomenon (see e.g. Szécsényi-Nagy 1980) the electromagnetic output of the star increases considerably. Taking into account the immense crowd of red dwarf (dK and dM) stars and the increasing frequency of flare stars among them it seems to be justified to evaluate the overall contribution of these tiny objects to the total photon density produced by stars in the Milky Way.

2. THE STELLAR CONTENT OF THE GALAXY

For the facts mentioned above it is enough to refer to the luminosity or mass function of the solar neighborhood in order to characterize the star population of the Galaxy. These functions were deduced from the results of star counts which lead to very similar conclusions irrespective of the volume studied. The main point is that the counterparts of the dimmest red dwarfs (dM2-dM8 stars) were found not only in the solar vicinity but in stellar clusters and associations too. Their absolute visual brightness ranges between $M_V = +10$ and $M_V = +18$ and if we add the distance moduli of the aggregates to these values it will be clear why it is so difficult to observe these objects. But they have an advantageous property: many (or all) of them show flareups. During these periods, their luminosity increases so significantly that we are able to detect them with moderate-sized telescopes. By photographically patrolling well-specified sky-fields in the ultraviolet passband, astronomers participating in this concerted work identified hundreds of these otherwise unnoticeable objects. What is more, based on the random nature of the flaring process it was also possible to estimate the number of those flare stars in the above fields which had not produced any observable outburst yet (the latent flare

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stars). In this way it was shown that at least the younger clusters must contain approximately an order of magnitude more stars than was generally accepted. The population of the Pleiades, for example, may well contain up to 1500-3000 stars. The Orion-association and many other well-scrutinized aggregates may also have a substantially larger number of stars than previously believed (Szécsényi-Nagy 1986).

Some recently published statistical investigations lead to the same conclusions. D'Antona and Mazzitelli (1986), Hawkins (1986) or Jahreiss (1988) showed that the luminosity function turns up at faint magnitudes as a consequence of the contribution provided by the lowest mass stars known.

3. ELECTROMAGNETIC EMISSION FROM FLARE STARS

Flare stars were identified among dK and dM spectral types in the +6.5 – +18.0 M_V range. They are relatively rare in early K classes but their flareups are much more energetic than those of late M-type stars. The latter are emission-line objects too and this means hydrogen Balmer-emission. It was shown by Petit (1961) that the fraction of dMe stars among the M dwarfs increases rapidly towards the end of the spectral sequence. Joy and Abt (1974) concluded that all of the stars later than dM5.5 are dMe stars and that their percentage is about 50% at dM4.5. Among early dM stars the fraction of emission objects drops rapidly to about 8–10%. As the spectral sequence runs with the M_V-values dMe stars overpower the non-emission stars from $M_V = 12.5$. At the moment we do not have enough data to determine the fraction of flare stars among objects of various spectral subclasses mainly because those dim stars were not patrolled for satisfactorily long intervals, but it seems very probable that all of the dMe stars will show flareups sooner or later. Non-emission stars can flare up too.

Flare stars in their quiet state are fainter in the U band than in the B and much fainter than in V. The contribution of these objects to the integrated electromagnetic flux produced by stars of the Galaxy (computed from the bolometric magnitudes of the objects and two-dimensional luminosity functions) is in the 2–4% range. Taking into account that the most active flare stars are able to provide about 10–20% more energy as a consequence of their outbursts the total contribution of the red dwarfs cannot exceed 5% of the photon production of galactic stars. But the spectra of flare stars and especially of the outbursts are very different from that of the "average" starlight. In the emission of the dMe stars and the flareups an incredibly high fraction of the total energy can be radiated in hydrogen Balmer-line (Herbst and Miller 1988). The most important of these features is the H-alpha line which gives more than 50% of the total line emission in the light of dM2e or later stars. As brighter stars are normally absorption-dominated and the very hottest stars which do not show Balmer absorption are extremely rare, this faint but numerous and active star-type can be accounted for up to 17–22% of the H-alpha light emitted by stellar objects.

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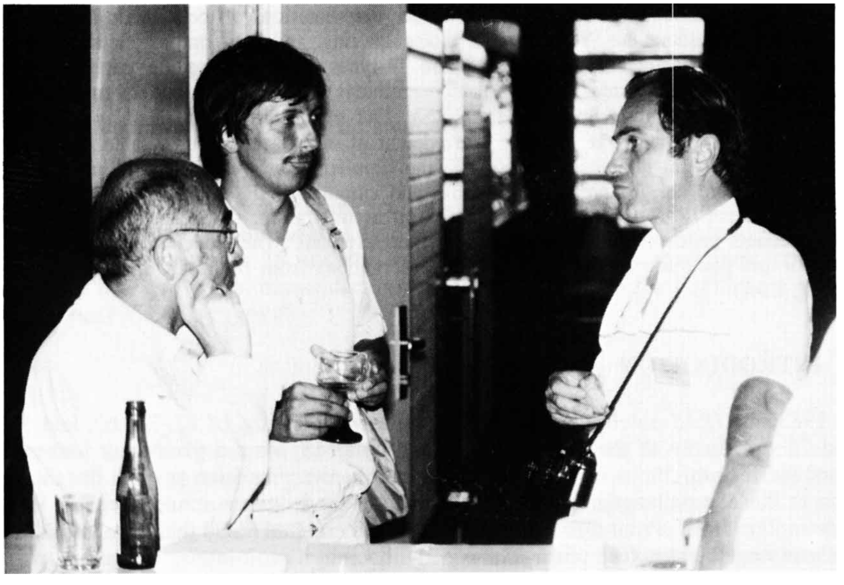
M. Harwit: *For a given field of view in the sky do you know what the temporal frequency spectrum for brightness variations would be due to flaring by the stars?*

G. Szecsenyi-Nagy: The frequency spectrum of individual flare stars is very far from any standard. To say something quantitative, the frequency of stellar flares of an energy excess of 10^{30} ergs (integrated light) is about 1 hr^{-1} and that of an energy excess of 10^{32} ergs can be 0.1 hr^{-1}. Unfortunately the distribution of high-energy flares is only partly known because their detailed study requires very long and preferably continuous photometric or spectrophotometric observations. But we know that in young stellar aggregates (e.g., in the Orion-association or the Pleiades) these chromospherically active objects provide high excess energy mainly due to their most energetic outbursts. In general you can expect one event per square degree at medium galactic latitudes in the 1–100 h range. Again, the more frequent outbursts provide only a practically unobservable amount of excess energy and it is the rarest events which produce a real brightness increase of the field.



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