FLARE-LIKE ACTIVITY OF RED GIANT STARS

Robert E. Stencel
Joint Institute for Laboratory Astrophysics, University of Colorado and National Bureau of Standards, Boulder, CO 80309

ABSTRACT

Evidence for magnetic surface activity among cool stars of low gravity is discussed.

I. INTRODUCTION

In this colloquium dedicated to surface activity on red dwarf stars, it may be useful to comment on evidence for flare-like activity among higher luminosity cool stars: red giants and supergiants. Although the canonical view is that the rotational angular momentum has been dissipated from the envelopes via massive stellar winds, both their rapid evolutionary timescale and core dynamics might be capable of substantial dynamo regeneration of magnetic fields. Emerging magnetic flux means surface activity for cool stars, regardless of the surface gravity.

There is a profound difference in the structure of the outer atmospheres of red giants compared to red dwarfs. Main sequence stars are known to be solar-like, with geometrically thin chromospheres and thick coronae, plus spots and flares. Red giants and supergiants, in contrast, appear not to have any coronal temperature plasma, but are enveloped by a vast chromosphere which extends out several stellar radii. There is now spectroscopic and direct evidence for these geometrically extended chromospheres surrounding red giant stars (cf. Stencel 1982). The large mass loss/stellar winds of the red giants may be analogous to open magnetic field regions on the Sun.

II. MAGNETIC ACTIVITY?

Is there evidence for flares on red giants? Among red giants, observations of Ca II H&K (Reimers 1977), Mg II h&k (Mullan and Stencel 1982) and He I 10830 Å (Zirin 1982) lines have revealed profile and flux variations. The timescales for variations are as short as 10^4 sec, while others occur between observing seasons (10^7 sec). Synoptic observations (Baliunas et al. 1981) will be required. In the Mg II study with Mullan, we observed several cool giants and supergiants repeatedly during three years with <u>IUE</u>, and found variation in total emission

P. B. Byrne and M. Rodonò (eds.), Activity in Red-Dwarf Stars, 251–254.

strength, or strength/velocity of circumstellar Mg II absorption. The current statistical sample is small and no conclusion about extremes of such events can be drawn at present. Even so, the inferred energy release probably is comparable to that of a modest red dwarf flare, but on a longer timescale.

Boice et al. (1981) reported a radio flare on the red giant Alpha Ceti, which peaked at ten million times the surface flux of a large solar flare. Hayes (reported by Goldberg et al. 1982) has measured polarization changes in the red supergiant Alpha Ori which were correlated with changes in the brightness distribution of the extended chromosphere revealed in narrow band (H-alpha) speckle interferometry. These limited synoptic data suggest that among red giants and supergiants, flare-like events occur on timescales of 10^4-10^7 sec, with associated luminosities of 10^{30} to 10^{36} ergs/sec. While the luminosity changes are flare-like, the timescales seem much larger than for red dwarf stars.

These events can be interpreted using magnetic topology arguments (Mullan 1982). High gravity stars are capable of maintaining stable, closed magnetic loops which aid production of coronal temperatures. Low gravity stars do not permit emerging magnetic flux loops to find stable, closed configurations, and flux continues to emerge, experiencing reconnection and subsequent forcing out of plasma in a stellar wind. The associated "flares," which may have velocities similar to the circumstellar material (e.g. 50 km/sec) on timescales mentioned, thus have characteristic lengths of appreciable fractions of giant and supergiant stellar radii. Observed line variations, speckle interferometry and polarization argue for atmospheric inhomogeneities in red giant chromospheres which are comparable to the stellar radius. Synoptic photometry and spectroscopy will help to clarify this intriguing situation, and whether or not similar flare physics is involved in giants and dwarfs.

REFERENCES

Boice, D. C., Kuhn, J. R., Robinson, R. D., and Worden, S.P.: 1981, Astrophys. J. 245, p. L71.

Baliunas, S., Hartmann, L., Vaughan, A., Liller, W., and Dupree, A.: 1981, Astrophys. J. 246, p. 473.

Goldberg, L., Hege, E. K., Hubbard, E. N., Strittmatter, P. A., and Cocke, W. J.: 1981, in "Second Cambridge Workshop on Cool Stars, Stellar Systems and the Sun," ed. M. S. Giampapa and L. Golub, S.A.O. Special Report 392, p. 131.

Mullan, D. J.: 1982, Astron. & Astrophys. 108, p. 279.

Mullan, D. J. and Stencel, R. E.: 1982, Astrophys. J. 253, p. 716.

Reimers, D.: 1977, Astron. & Astrophys. 57, p. 395.

Stencel, R. E.: 1981, in "Second Cambridge Workshop on Cool Stars, Stellar Systems and the Sun," ed. M. S. Giampapa and L. Golub, S.A.O. Special Report 392, p. 137.

Zirin, H.: 1982, Astrophys. J. (submitted).

https://doi.org/10.1017/S0252921100096184 Published online by Cambridge University Press

DISCUSSION

Feldman: Whitworth(?) and Hughes once observed a 0.25 Jy flare in R Aql and then spent the next 3 years trying to find another, unsuccessfully. So I would suggest that these specifically radio events are quite rare.

Stencel: That would be consistent with other reports and indeed that is why the information I report is so stetchy.

Popper: I am having a little trouble with terminology. In using the term "red giant" you lump together stars of very different radii and luminosity. For istance, you talked about α Cet, which most astronomers would call a giant, and about α Sco or α Ori,which we would call supergiants. It is my impression that giants are, in terms of atmospheric structure, more like Main Sequence stars then they are like supergiants. When you talked of a flare on α Cet you then talked about the sizes and structure of the chromospheres and supergiants. So giants and supergiants are very different and should be clearly distinguished.

Stencel: Absolutely. Certainly the spectroscopic criteria which distinguished luminosity classes are well founded. In X-rays however there is not yet a way of distinguishing between red giants and supergiants. They both have an almost complete lack of coronal gas and both possess extended chromospheres. So in that sense they are similar. So please excuse me using a common notation. I should have specified giants and subgiants in all cases.

Oskanian: Did I understand properly that the flares you showed us last for 1 day or even more? How then could you decide that these were flares and not some other kind of changes on the stars?

Stencel: In the case of α Ori, for example, the light curve indicates an event of several days duration. In other cases the flickering was on a timescale of hours but its overall shape was not adequately defined in the published data.

Oskanian: I can add to this. On the star μ Cep, a supergiant, Asenievich in Belgrade has observed a real flare lasting several minutes. I have seen the traces and it is a real flare in V. I also had the opportunity to observe once on a giant star, that is, a luminosity class III star, and it flared twice. There are also other giant stars on which I know other people have observed flares of duration a few minutes. I have also observed longer timescale changes on these types of star which may not be flares but other kinds of changes. So we need more proof in order to call these phenomena flares. We know the characteristic of flares well enough.

Stencel: I wish that more of these observations were reported in the widely circulated journals. At the present they simply comprise rumours and stories. The importance of these variations, whatever their true nature, solarlike flares or otherwise, is that they evidently propagate through the entire atmosphere of the stars from a disturbance low in the atmosphere. This latter disturbance could be related to the release of magnetic energy.

Jordan: Can I suggest that you do not call these variations flares because these variations, which may be seen in the optical to radio wavelengths, are not accompanied by any changes in the transition region fluxes, such as C IV, or in the X-ray flux. Schwarzschild and others showed quite some time ago that the scale of the supergranulation on these giants and supergiants is vast compared to that on the Sun. In fact one convective cell could cover almost the entire visible hemisphere of such a star. It is quite plausible that whatever weak magnetic field is there concentrates into the boundary regions of such cells and that these magnetic fields periodically rearrange themselves. There it seems reasonable to me that these events should release small amounts of energy into the low chromospheres. That is an entirely different matter from what we would normally call a flare in which the whole corona and chromosphere is involved. So it is not that I do not believe that what you are seeing is interesting but you should be very careful about calling them flares.

Stencel: Data from Reimers on variations in the transition regions lines of hybrids may contradict your suggestion that there are no variations of that sort.

Jordan: You hadn't mentioned hybrids. You only mentioned the very cool giants and supergiants with extended atmospheres. I recall that the hybrids have steep transition regions.

Collier: Last year in July a programme of monitoring RS CVn candidates at 6 cm wavelength was carried out. Among them was an object HD 101379 which is a K IV giant. Photometric investigations have derived a radius of about 40 solar radii and a rotation period of about 60 days. On one day out of 8 days of monitoring it showed an enhancement of about a factor of 3 in its radio emission at 6 cm up to about 70 mJy. Simultaneous high resolution spectroscopy at Mt.Stromlo showed an enhancement in the red wing of Hα at the same time. This may be symptomatic of the same kind of thing. The time scale was of the order of 8 hours to 1 day.

Stencel: Please publish your results.