A NEW TRIGGERING MECHANISM FOR RED DWARF FLARES

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The flare phenomenon associated with dMe stars has received much attention in recent years (Gershberg 1975). Most of the flares have been detected in both optical and radio band (Lovell 1969; Kunkel 1974; Karpen et al, 1977). But as expected (Tandon 1976) only a few display weak soft X-ray emission (Karpen et al, 1977; Haisch and Linsky 1978). Simultaneous X-ray, optical and radio observations of YZ CMi by Karpen et al (1977) shows no X-ray emission above 3σ level accompanying minor flares. Even coincident X-ray coverage with seven radio bursts shows no enhanced X-ray emission. Recently Haisch et al (1981) detected one well resolved X-ray flare on dM5e flare star Proxima Centauri and one coincident optical and radio flare out of five optical and twelve radio flare events. However, the X-ray flare on Proxima Centauri is not accompanied by any ultraviolet, optical or radio emission. Observations on flare stars show that they are more energetic, 10^2 - 10^3 times, than the corresponding solar flares. Considering the flare activity in dwarf M-stars to be similar but more energetic to that of a large solar flare, Tandon (1961) proposed red dwarf flares to be the source of low energy galactic cosmic rays. This hypothesis has been reexplored recently by Lovell (1974).

Generally a solar flare type mechanism is envisaged to explain the red dwarf flare phenomenon (Gershberg 1975). It may be noted, however, that during the flare the ratio of energy output in the radio wave band to optical continuum in general is much greater than from the Sun. To explain the enhancement in the total optical magnitude during the flare through a solar type mechanism, Kahn (1974) showed that one requires extremely relativistic electrons $\sim$300-500 MeV gyrating in a magnetic field $\sim$ 900 gauss on the star's surface. On similar lines Mullan (1974) linked the stellar flare on YZ CMi with stellar spots carrying magnetic fields of approximately 20 kilogauss: If such a strong magnetic field prevails on the star, one must be able to measure the

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optical polarization. However, recent observations on two spotted BY Dra and EV Lac by Petterson and Hsu (1981) and on five UV Ceti and BY Dra by Clayton and Martin (1981) show no linear or circular polarization. It may be remarked that the theories of red dwarf flares based on solar flare mechanism envisages detectable enhanced X-ray emission. Since so far there are no definite evidence of accompanying X-ray flares on these stars, a reconsideration of the problem is called for. In this small note, we therefore, propose an alternative model for the flare activity in dwarf M-stars.

Most of the M dwarf stars are known to be low mass stars. The star must have begun its life from a contracting, gravitating interstellar mass and that the proto-star must have acquired both rotation and magnetic field of the interstellar matter from which it evolved. We assume the magnetic field energy in the interior to be sufficiently large so as to survive the Hayashi turbulence. From the evolutionary track of low mass stars (0.3 - 0.4 M_o) (Ezer and Cameron 1967) it can be seen that these stars cease to be wholly convective and a radiative core (approximated as a polytrope of index n=3) forms after about 20-50 million years. With contraction the central temperature rises to about (5-8) x 10^6K exciting thermonuclear processes inside the newly formed small central convective core. The equilibrium magnetic field inside the core can therefore be approximated as that of a magneto-rotating polytrope of index n=1.5. With subsequent rise in temperature (10-13)x 10^6K due to enhanced energy production the size of the convective core increases to its maximum and further the interaction of rapid mass-motion or differential rotation with the primeval magnetic field results in the generation of a mainly toroidal component H_ϕ of the magnetic field inside the core. Therefore, the ratio of toroidal to poloidal of the magnetic field in the stellar core increases. Due to this and increased core size the magnetic field in the thin radiative region cannot remain in equilibrium with the magnetic field inside the core and subsequently with that existing in the outer convective zone, since the equilibrium magnetic fields for n=1.5 and n=3 are different (Das and Tandon 1976). In order to restore equilibrium, strong pressure waves propagating from the interior along the magnetic field lines will plunge into the outer convective layers of the star and might lead to an outburst. The mass ejecta of the order of 10^{-8} to 10^{-6} M_o associated with the moving pressure waves with velocities of a few km per sec. will release energy of the order of 10^{35} - 10^{37} ergs. It may be added that these strong pressure waves derive their energy as a result of an increased rate of release of nuclear energy inside the core. This process is expected to be a piecemeal one with one to several flares at its initial stage. A fraction of the energy released through mass ejecta is capable of enhancing the total luminosity of these red dwarf stars by a few magnitudes and exciting a shock wave in the stellar chromosphere leading to accompanied enhanced radio emission. Since the size of the radio flare will be much larger than that of the optical flare, the ratio of radio to optical output of energy will be much larger. This mechanism does not envisage associated large X-ray emission during the flare and further does not require large surface magnetic fields on these stars.

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DISCUSSION

Rosner: I do not understand exactly what you are trying to explain. Are you trying to explain the white-light emission in the flares or what?

Das: We are trying to predict the optical continuum which is being generated. The bulk of the star is involved because pressure waves propagate in all directions in the envolope.

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