Short-Duration Flares on Mira Stars

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Mira stars are slowly pulsating red giant stars with periods of order a year, so it came as a startling surprise when they were discovered to have short-duration flares (Schaefer 1991). These flares were observed with amplitudes 0.4 to 1.4 mag and durations from 3 minutes to 3 hours, and were visible in both the optical and the radio. Mira flares have been confirmed by Maffei & Tosti (1995), de Laverny et al. (1998), and Stencel et al. (2003), with flare durations lasting up to 6 days. However, studies by Mais et al. (2004), Wozniak et al. (2004), and Lebzelter (2011) have failed to find any flares on various samples of red giants. It is currently unclear what subset of Mira stars and what phases show flares, no detailed models have been made, and we have poor knowledge of flare demographics. Models of Mira flares (e.g., Struck et al. 2002) point to magnetic reconnection involving planets orbiting the Mira star.

I propose to have Kepler monitor Mira stars during the K2 mission for Field 2, with the 30-minute cadence, with the goal to be to discover flares from a few minutes to days in duration. (Even with a 3 minute flare, a 0.1 mag amplitude event would be easily detected as a 10 millimag event which should be highly significant.) The analysis would be to subtract a long-term spline-fit to the light curve, make running box-averages over a wide range of bin-sizes, and seek flares above a 5-sigma significance level (after accounting for the number of trials and bins searched). For flares found, amplitudes, durations, phases, energy estimates, and light curves would be published, along with demographic results like size-frequency distributions.

The original Kepler mission did look at 317 M giant stars, but this includes only two classic Mira stars (Banyai et al. 2013). They do not report any flares, but they only report on Fourier transforms for periods longer than a day, so this study does not seem to be sensitive to Mira flares. Nevertheless, this study provides a proof that Kepler can follow Mira stars with 30-minute time resolution and ~0.1 millimag accuracy. Only 3 Miras are being observed as part of my K2 Field 0 proposal.

I have selected 30 targets, all confirmed Mira variables inside Field 2. I selected only those that are *always* brighter than V=16, to ensure good photometric accuracy, and to avoid biasing against flares near minimum. (Both Fields 1 and 3 have no useable Mira stars.) All targets are on-chip by *K2fov*.

Ground-based light curves are notoriously difficult to find small rare flares, while the Kepler satellite solves this due to having sub-millimag accuracy and a relentless light curve without gaps for many months. So Kepler is unique at being able to address the many big unknowns regarding Mira flares. This small K2 program will increase the number of Mira stars monitored by Kepler from 3 to 33, and so will make such a big advance that it has the potential for solving many of the questions. K2 will provide the first accurate and full-coverage light curve for the startling flares on Mira stars, and the large numbers of targets in Field 2 will allow real demographic studies, like flare frequency/size/duration as a function of Mira type, period, and phase.

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