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Modelling the rotation period distribution of M dwarfs in the *Kepler* field

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Abstract
McQuillan et al. (Mon. Not. R. Astron. Soc.432:1203, 2013) presented 1570 periods P of M dwarf stars in the field of view of the *Kepler* telescope. It is expected that most of these reflect rotation periods, due to starspots. It is shown here that the data can be modelled as a mixture of four subpopulations, three of which are overlapping log-normal distributions. The fourth subpopulation has a power law distribution, with $P^{-1/2}$. It is also demonstrated that the bulk of the longer periods, representing the two major sub-populations, could be drawn from a single subpopulation, but with a period-dependent probability of observing half the true period.

1 Introduction
The primary aim of the *Kepler* mission (e.g. Borucki et al. 2010) is the detection of extrasolar planets, through the photometric signatures of their transits across the faces of their host stars. However, the well-sampled and near-continuous lightcurves of the thousands of stars in the field of view can be used for a variety of other purposes. McQuillan et al. (2013) extracted periods of M dwarfs from the *Kepler* database. Most of these periods are expected to reflect the stellar rotation periods. For an extension to higher temperature stars see McQuillan et al. (2014). Other recent relevant papers are by Hawley et al. (2014), Kado-Fong et al. (2016), Newton et al. (2016), Davenport (2017) and Rebull et al. (2017).

The aim of this paper is to rigorously model the distribution of the *Kepler* M dwarf periods P. As will be seen below, this may shed light on the number of sub-populations in this sample of cool dwarfs, as well as their individual spread in periods. This statistical summary of the data can also facilitate comparison with similar data which may be obtained in other parts of the sky.

Histograms of the periods, and their log-transforms, are plotted in Fig. 1. (Note that logarithms are to the base e: this is standard for the likelihood statistics discussed below, and using the same base throughout avoids ambiguity.) A cursory inspection shows at least three groupings: a roughly exponential distribution of periods below about 8 d; a narrow Gaussian centered on about 18 d; and a broad Gaussian with a mean in the range 30–40 d.

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