Analysis of Memory and Governing Process and Exploration of Chaos and Self Organized Criticality in Solar Radio Flux Data

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The radio emission from the Sun at a wavelength of 10.7 cm is a measure of the solar flux density at the 10.7cm wavelength observed at the Earth by radio telescopes called flux monitors near the peak of the observed solar radio emission. Emission from the Sun at centimetric (radio) wavelength is primarily due to coronal plasma trapped in the magnetic fields overlying active regions. This in turn is related to the amount of magnetic flux. Also the solar radio flux index has been found to correlate well with the Sunspot number. For the analysis we have taken the daily data of solar radio flux at a wavelength of 10.7 cm ranging from 14 February 1947 to 31 March 2015 observed at National Research Council and Natural Resources, Canada with support from the Canadian Space Agency, previously known as Dominian Radio Astrophysical Observatory (DRAO) at local noon in a bandwidth of 100 MHz. The units are in solar flux units (1 s.f.u.= 10^{-22} m^{-2} Hz^{-1}).

To overcome the trend inherent to the present signal Double Exponential Smoothing (DES) is used. Next to remove irregular fluctuations in the signal we have gone for monthly average over the obtained smoothed signal. To investigate the flow of memory in the signal that is to examine the effect of past observations on the current observation and to determine how long the effect of current observation persists on the future entries R/S method is applied on the present signal.

The autocorrelation coefficients at different lags are computed to inspect whether the signal is stationary or non-stationary. Yule-Walker equations are framed and that system of equations is solved to identify whether the signal is governed by an autoregressive process [1].

The 0-1 test [2, 3, 4] is done to detect whether the solar radio flux signal has chaotic nature or not. Finally we inspect whether self organized criticality (soc) [5] is present in the signal or not.

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The present radio flux signal shows short memory i.e. anti-persistent behaviour. It is governed by a stationary autoregressive process of order 1 or AR (1) i.e. by a Markov process. The signal shows chaotic behaviour. Hence long term prediction cannot show reliable results. Only short term predictions can be possible. The signal exhibits soc which fuels the possibility that the mechanics of trapping of coronal plasma in the magnetic fields overlying active regions is a slowly driven non-equilibrium system with extended degrees of freedom and a high level of nonlinearity. This also indicates that the governing mechanics of trapping of coronal plasma may exhibit avalanche-like energy dissipation. The present result also indicates a possible existence of self-regulatory internal mechanisms that drive the system spontaneously to a statistical stationary state. The resulting organization is possibly distributed over all the components of the system. As such it is typically very robust and able to survive and self-repair substantial damage or perturbations.

In fine, the present study deals with the short memory dynamics of coronal plasma trapped in the magnetic fields overlying active regions and the governing process appears to be governed by AR (1) exhibiting chaotic behaviour and soc.

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