

# Dynamics and Universal fluctuations of the Wolf's sunspot numbers

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## Abstract

Bramwell, Holdsworth and Pinton discovered the probability density function (pdf) (named BHP after them) for the fluctuations of the total magnetization, in the strong coupling (low temperature) regime for a two-dimensional spin model (2dXY), using the spin wave approximation. The BHP pdf does not have any parameter and it is universal, in the sense that it appears in several physical phenomena. Under the hypothesis of a mean cycle length of 133 months we describe statistically the Wolf's sunspot numbers one-dimensional dynamics. Surprisingly, we observed that the Wolf's sunspot numbers fluctuates according to the universal BHP pdf. We discovered that in a Ruelle-Takens embedding setting of the Wolf's sunspot numbers, the empirical distribution of the predicted normalized first difference revealed a good fit to the BHP pdf. Like this, we link the randomness of the Wolf's sunspot numbers dynamics, a natural and complex dynamical system, with the universal BHP pdf.

**Keywords:** Dynamical Systems; BHP universality, Sunspots.

**PACS codes:** 96.60.j, 96.60 qd, 96.60.Ly, 05.65.+b.

## References

- [1] Bramwell, S.T., Holdsworth, P.C.W., & Pinton, J.F. Universality of rare fluctuations in turbulence and critical phenomena, *Nature* **396**, 552–554, (1998).
- [2] Bramwell, S.T., Christensen, K., Fortin, J.Y., Holdsworth, P.C.W., Jensen, H.J., Lise, S., López, J.M., Nicodemi, M. & Sellitto, M., Universal Fluctuations in Correlated Systems, *Phys. Rev. Lett.* **84**, 3744–3747, (2000).
- [3] Gonçalves, R., Pinto, A. and Stollenwerk, N., River Durius and Danube daily water level fluctuations submitted
- [4] Kantz, H. and Schreiber, T., *Nonlinear Time Series Analysis*. Cambridge Univ. Press, (1997).