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Criticality during boiling crisis: Acoustic emission avalanches

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Among known hydrodynamic instabilities, boiling crisis is one of the most poorly understood [1]. It may be described as a sudden loss of liquid contact with a heating surface (dryout) when a small increase of heat flux transforms nucleate boiling regime into film boiling reaching the critical heat flux results in thermal blocking and temperature increase with often devastating consequences for various nuclear and electronic systems (burnout). In this work [2] we study boiling crisis from a fundamental point of view because it marks a transition between two different non-equilibrium dynamic steady states, each incorporating liquid flow, phase transition, contact line dynamics and heat transfer. At subcritical values of the heat flux separate bubbles are released from the hot surface (nucleate boiling), while at the CHF a vapor layer suddenly covers the hot surface. At supercritical heat flux values the system stabilizes again in a film boiling regime where bubbles are released from a detached liquid vapor surface. We present an experimental study (based on the Acoustic Emission technique) of intermittancy and avalanche distribution during boiling crisis. To understand the emergence of power law statistics we also propose a simple spin model capturing the measured critical exponent. The model suggests that behind the critical heat flux there is a percolation phenomenon involving drying-rewetting competition close to the hot surface.

[1] V.K.Dhir, Annu. Rev. Fluid Mech. 30, 365 (1998) [2] P. Lloveras, F. Salvat-Pujol, L.Truskinovsky and E.Vives, Phys. Rev. Lett.108, 215701 (2012).