The working of ductile metals and the doctrine of maximum entropy.

The work-hardening of metals exhibits a precursor phase, a self-organised-critical phase, and an exhaustion phase; occasionally, even a born-again phase. All of these involve intermittent flow and symmetry breaking. One can relate this to coarse-grained engineering variables such as plastic strain which show an 'infinitesimal' increment large enough to keep the system always in a critical state. A repeated theme in understanding all of these is the tendency for complex mechanical systems to maximise the number of pathways available in response to large external forces. This is the doctrine of maximum entropy defined as a smoothed extensive thermodynamic quantity. The entropy is maximised subject always to the constraint of what processes are possible according to mechanics and the boundary conditions.

LMB

ENTROPY & SELF-ORGANISED CRITICALITY

- WORK-HARDENING OF DUCTILE METALS SHOWS SOC & CONSTANT INTERMITTENCY (AVALANCHES OF PLASTIC FLOW; SLIP BANDS)
- IF ENTROPY IS DEFINED AS (THE LOGARITHM) OF THE NUMBER OF WAYS THE METAL CAN RESPOND TO AN INFINITESIMAL INCREASE IN STRESS, MAXIMUM ENTROPY IMPLIES AVERAGED UNIFORM PROPENSITY TO AVALANCHES THROUGHOUT THE VOLUME
- NO OTHER PHYSICAL QUANTITY IS GERMANE SO ONLY A POWER LAW RELATING STRESS (INTRINSIC VARIABLE) TO ENTROPY (EXTRINSIC VARIABLE) IS POSSIBLE. SOC IS A PRODUCT OF THERMODYNAMICS.
- ALL OTHER AVERAGED EXTRINSIC VARIABLES e.g. STRAIN, STRAIN RATE, CELL SIZE IN MICROSTRUCTURE, etc. SHOW POWER-LAW RELATIONSHIPS WITH STRESS AND ‘SIMILITUDE’
- WORK-HARDENING RATE CAN BE CALCULATED DIRECTLY WITHOUT DETAILED INFORMATION ON MICROSTRUCTURE
- SEE ‘CONSTANT INTERMITTENT FLOW OF DISLOCATIONS: CENTRAL PROBLEMS IN PLASTICITY’ in MAT. SCI. & TECH. **28** (2012) p 1209.
- WE ARE SOMEWHERE BETWEEN NEWTON AND DARWIN
- IOP 05/12/12

Per Bak's famous sandpile