Modelling of fracture accumulation in high pressure composite vessel with use of fractal geometry

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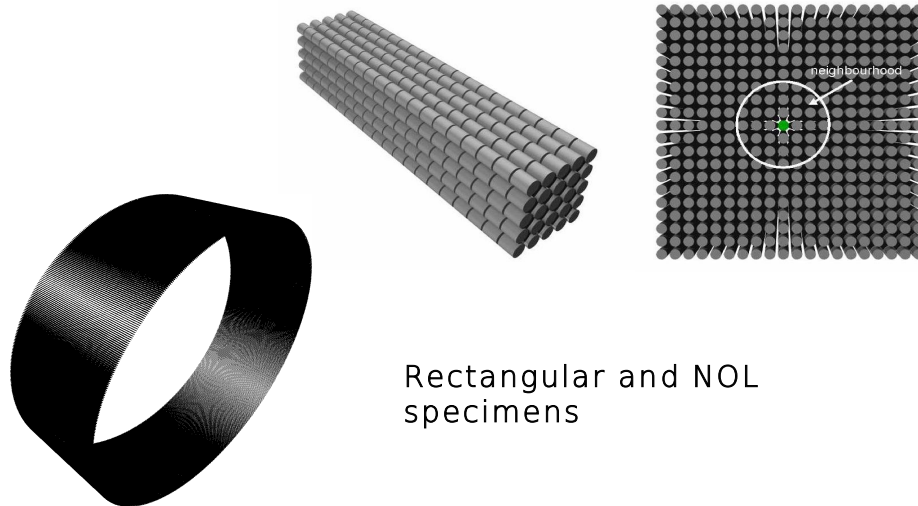
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- the cellular automata model of fibres in composite
- the idea of correlated defect
- the stochastic model of fibres break in composite
- the fractal characteristics of defects
- numerical simulations
- instability of defects growth (largest cluster)
- increase of life time for large load

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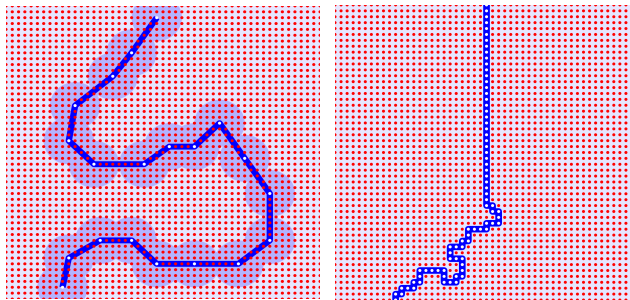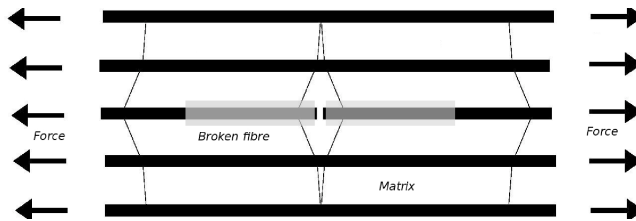# Cellular automata modelling fibers in composite

neighbourhood

Rectangular and NOL specimens

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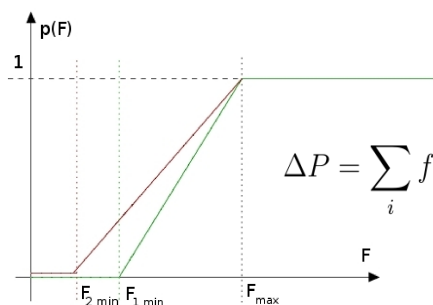## Stress concentration close to broken fibre
the idea of correlated defect
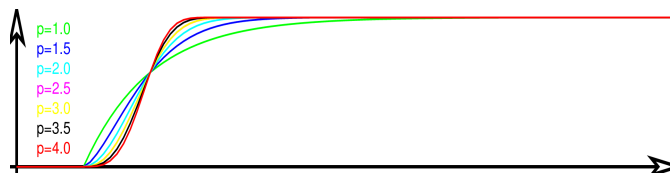
Force   Broken fibre   Force

Matrix

Percolation
of
correlated
defect

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The fibre break down probability
the Weibull function and its approximation

p=1.0
p=1.5
p=2.0
p=2.5
p=3.0
p=3.5
p=4.0

p(F)

1

$F_{2\,min}$ $F_{1\,min}$ F_{max} F

$$P(F) = 1 - \exp\left\{-\left(\frac{F}{a}\right)^{p}\right\}$$

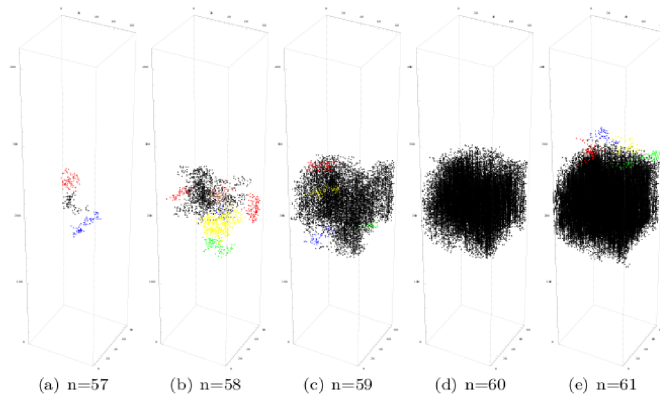$$\Delta P = \sum_{i} f(F, r_i), \qquad f(F, r) = A(F)\,(r + B)^{\alpha}.$$
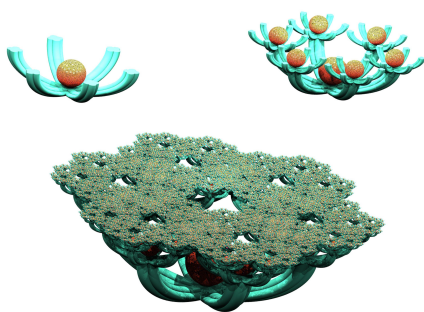
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Why fractals?

$$D_A > D_B \qquad A \cup B = C$$

Only the set with more complicated structure is visible in union

(a) n=57   (b) n=58   (c) n=59   (d) n=60   (e) n=61

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Why fractals?
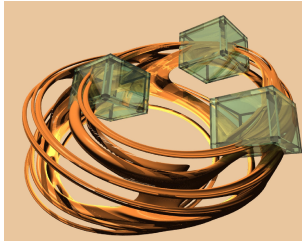

Recurrent construction of fractals

Fractal model of ceramics
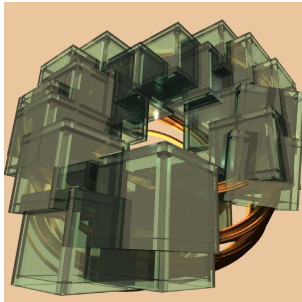
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Why fractals?

Minimal number N of short segments with length l necessary to cover the longer segment with length L equals:

$$N = \frac{L}{l} \propto l^{-1}$$

Minimal number of squares with side l necessary to cover the large square with side L equals:
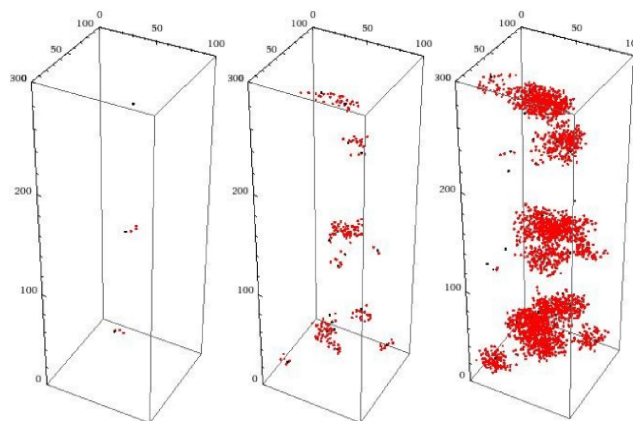
$$N = \frac{L^2}{l^2} \propto l^{-2}$$

The power exponent *D* is named

the "box-counting" fractal dimension

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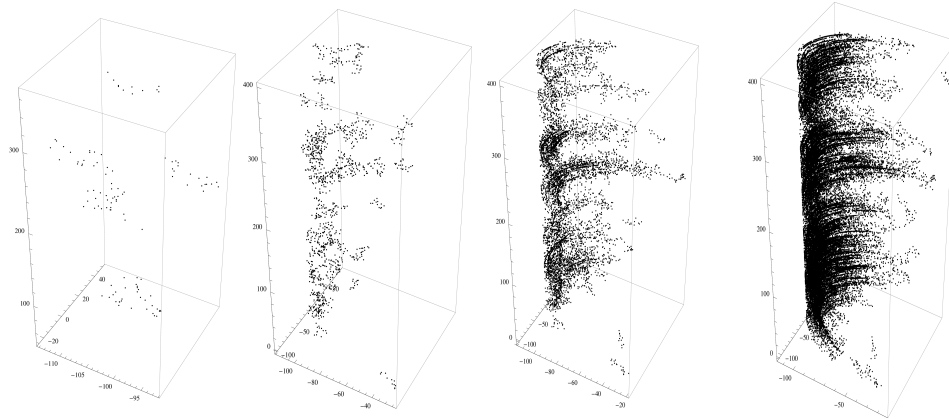
Numerical simulations

Evolution of the largest correlated defect

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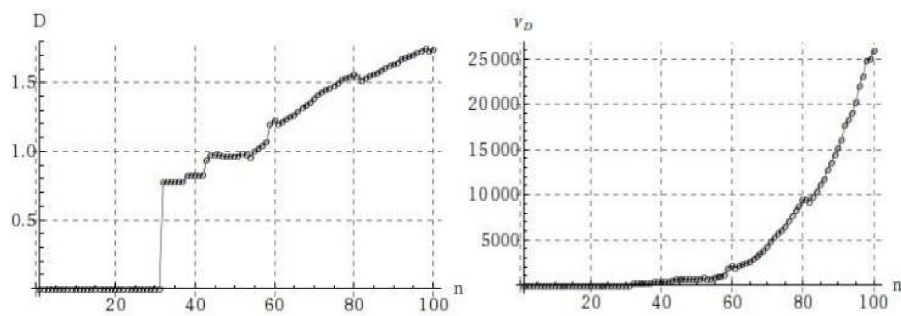## Numerical simulations, NOL specimen

Concentration of defects becomes
completely invisible

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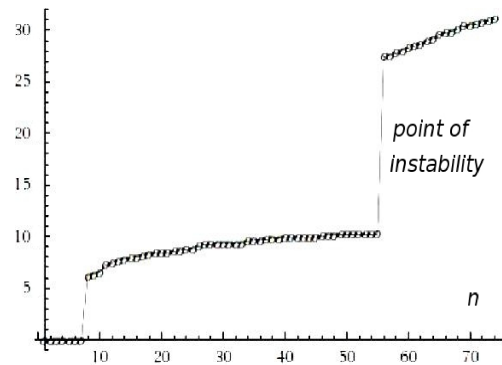## Plots of fractal dimension and pseudo measure

The instability appears at
approximately n=60

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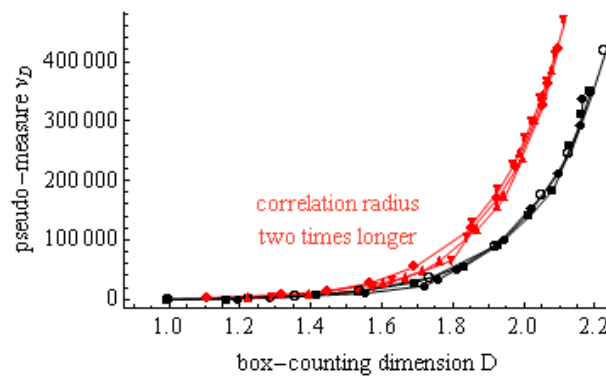# Critical instability of defects growth

The log plot of pseudo measure
indicating instability

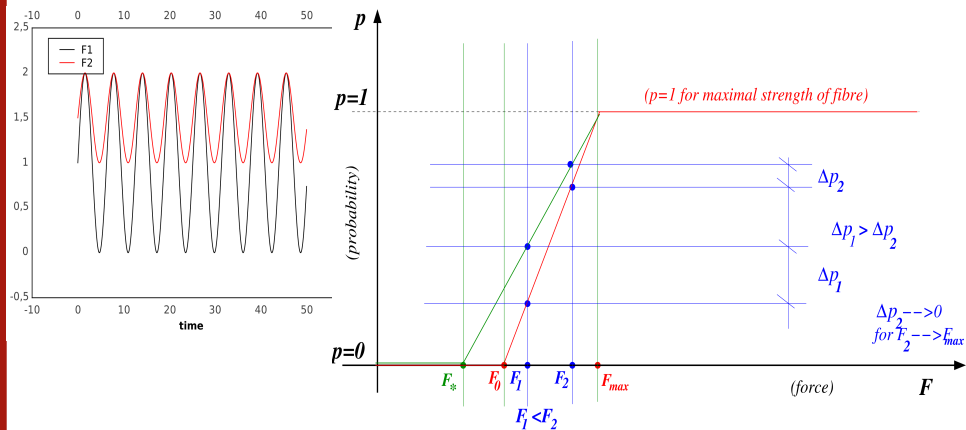Wrocław University of Technology

Critical growth of defects

The plot of pseudo measure is not very
sensitive to correlation radious

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The increase of life time due to slower cluster formation for large loads

The life time for vessel exposed to higher mean pressure can be longer comparing to vessel with lower load

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Thank you