

Statistical Characterisation of Porous Media at the Pore Scale

Parametric Models

Student:

Lukas Mosser

Supervisors:

Professor Olivier Dubrule

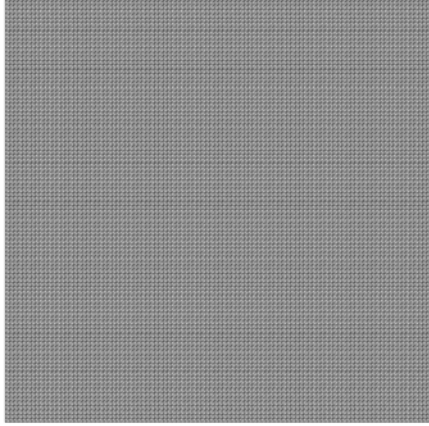
Professor Martin Blunt

Presentation Outline

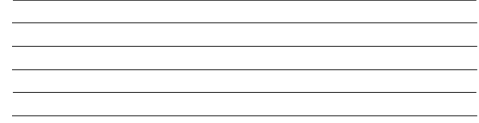
- **Plane Surface**
- **Bundle of Tubes**
- **Array of Spheres**
- **Asymmetric Array of Spheres**

Plane Surfaces

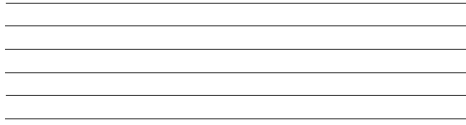
X-Y View



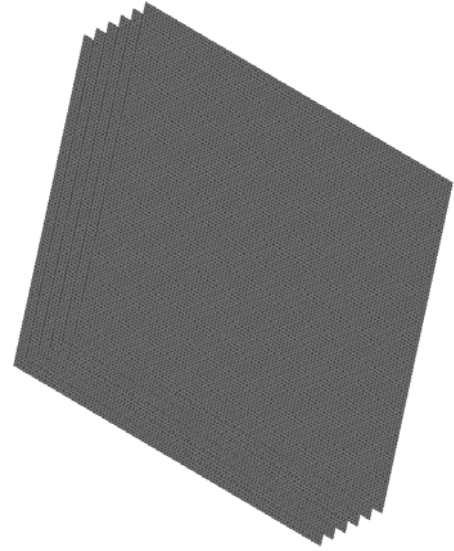
Y-Z View



X-Z View



3D View

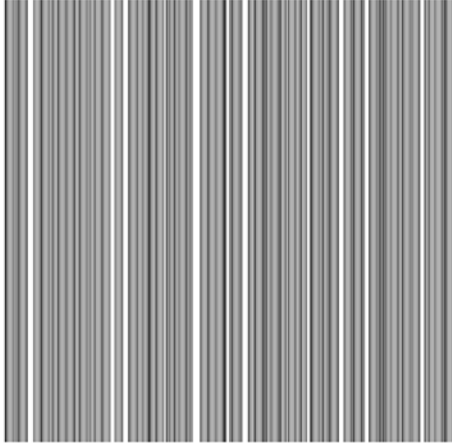


Minkowski Tensors – Plane Surface

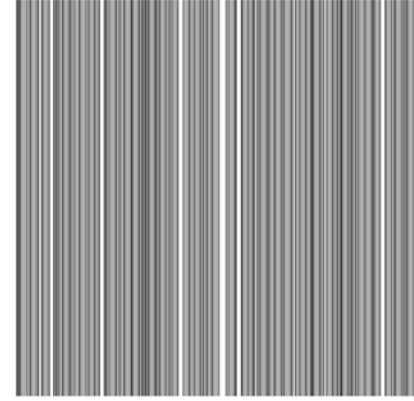
Minkowski Tensor	Eigenvectors	Eigenvalues	Anisotropy Index
$W_1^{0,2} = \begin{bmatrix} 0.0 & 0 & 0 \\ 0 & 0.0 & 0 \\ 0 & 0 & 2400. \end{bmatrix}$	$\begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix} \quad \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix} \quad \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$	$\{0.0 \quad 0.0 \quad 2400.\}$	$\beta_1^{0,2} = not \ def.$
$W_2^{0,2} = \begin{bmatrix} 0.0 & 0 & 0 \\ 0 & 0.0 & 0 \\ 0 & 0 & 0.0 \end{bmatrix}$	$\begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix} \quad \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix} \quad \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$	$\{0.0 \quad 0.0 \quad 0.0\}$	$\beta_2^{0,2} = not \ def.$

Bundle of Tubes

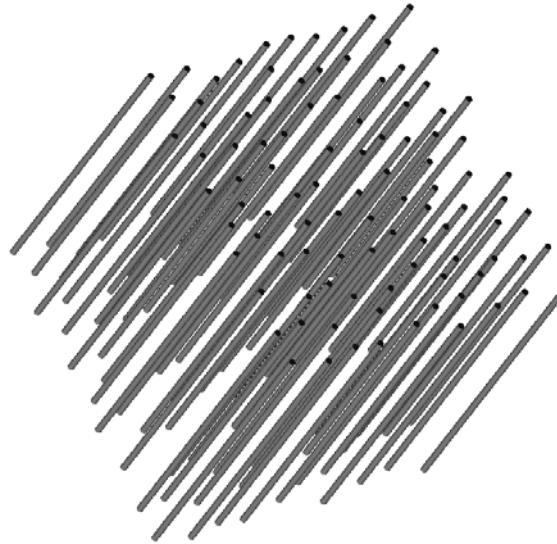
X-Z View



Y-Z View



3D View

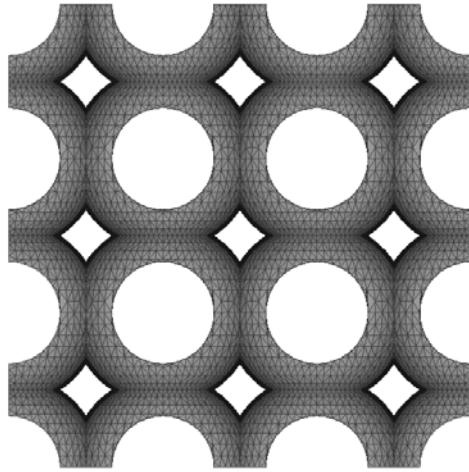


Minkowski Tensors – Bundle of Tubes

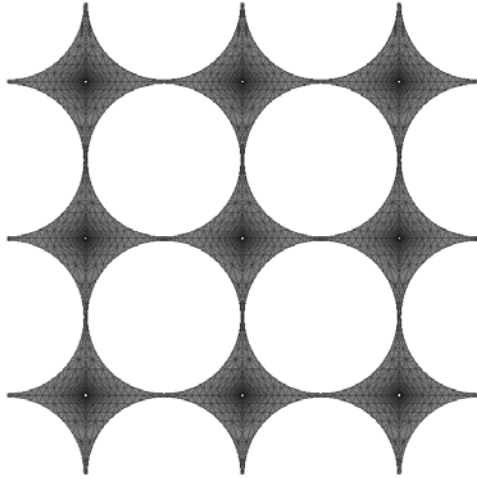
Minkowski Tensor	Eigenvectors	Eigenvalues	Anisotropy Index
$W_1^{0,2} = \begin{bmatrix} 10405 & 0 & 0 \\ 0 & 10405 & 0 \\ 0 & 0 & 0 \end{bmatrix}$	$\begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix} \quad \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix} \quad \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$	$\{10405 \quad 10405 \quad 0.\}$	$\beta_1^{0,2} = not \ def.$
$W_2^{0,2} = \begin{bmatrix} 4590 & 0 & 0 \\ 0 & 5228 & 0 \\ 0 & 0 & 0 \end{bmatrix}$	$\begin{bmatrix} -1 \\ 0 \\ 0 \end{bmatrix} \quad \begin{bmatrix} 0 \\ -1 \\ 0 \end{bmatrix} \quad \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$	$\{4590 \quad 5228 \quad 0.0\}$	$\beta_2^{0,2} = not \ def.$

Symmetric Parametric Pore

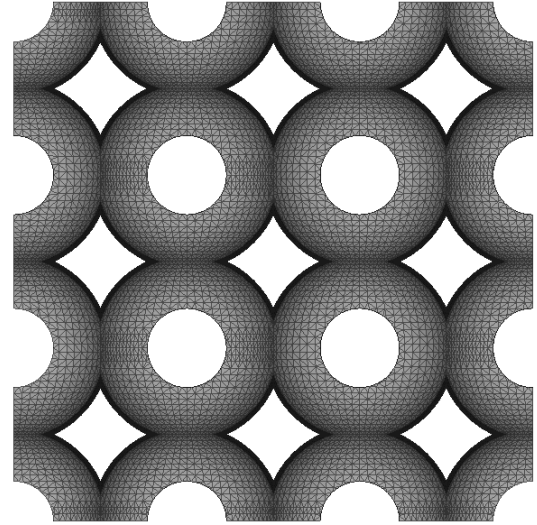
Radius 1.2



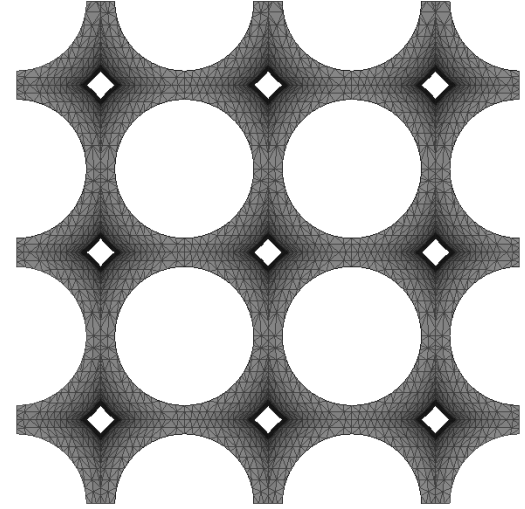
Radius 1.4



Radius 1.1



Radius 1.3



Minkowski Tensors – Radius 1.4

Minkowski Tensor	Eigenvectors	Eigenvalues	Anisotropy Index
$W_1^{0,2} = \begin{bmatrix} 10.6 & 0 & 0 \\ 0 & 10.6 & 0 \\ 0 & 0 & 10.6 \end{bmatrix}$	$\begin{bmatrix} -0.76 \\ 0.66 \\ 0 \end{bmatrix} \quad \begin{bmatrix} 0.66 \\ -0.76 \\ 0 \end{bmatrix} \quad \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$	$\{10.6 \quad 10.6 \quad 10.6\}$	$\beta_1^{0,2} = 1.0$
$W_2^{0,2} = \begin{bmatrix} -6.0 & 0 & 0 \\ 0 & -6.0 & 0 \\ 0 & 0 & -6.0 \end{bmatrix}$	$\begin{bmatrix} -1 \\ 0 \\ 0 \end{bmatrix} \quad \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix} \quad \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$	$\{-6.0 \quad -6.0 \quad -6.0\}$	$\beta_2^{0,2} = 1.0$

Minkowski Tensors – Radius 1.3

Minkowski Tensor	Eigenvectors	Eigenvalues	Anisotropy Index
$W_1^{0,2} = \begin{bmatrix} 19.6 & 0 & 0 \\ 0 & 19.6 & 0 \\ 0 & 0 & 19.6 \end{bmatrix}$	$\begin{bmatrix} -0.7 \\ 0.7 \\ 0 \end{bmatrix} \quad \begin{bmatrix} 0.7 \\ -0.7 \\ 0 \end{bmatrix} \quad \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$	$\{19.6 \quad 19.6 \quad 19.6\}$	$\beta_1^{0,2} = 1.0$
$W_2^{0,2} = \begin{bmatrix} -13 & 0 & 0 \\ 0 & -13 & 0 \\ 0 & 0 & -13 \end{bmatrix}$	$\begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix} \quad \begin{bmatrix} 0 \\ -1 \\ 0 \end{bmatrix} \quad \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$	$\{-13 \quad -13 \quad -13\}$	$\beta_2^{0,2} = 1.0$

Minkowski Tensors – Radius 1.2

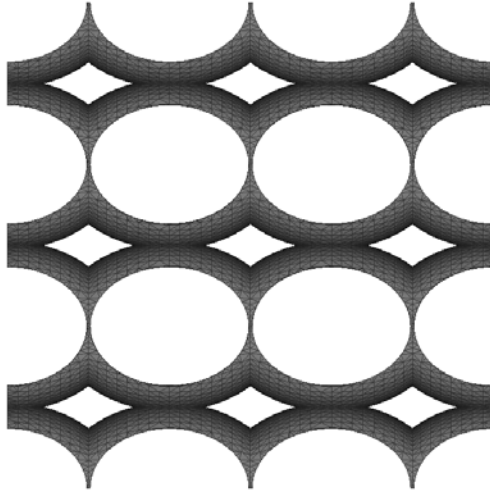
Minkowski Tensor	Eigenvectors	Eigenvalues	Anisotropy Index
$W_1^{0,2} = \begin{bmatrix} 27.1 & 0 & 0 \\ 0 & 27.1 & 0 \\ 0 & 0 & 27.1 \end{bmatrix}$	$\begin{bmatrix} -1.0 \\ 0 \\ 0 \end{bmatrix} \quad \begin{bmatrix} 0 \\ 0 \\ 1.0 \end{bmatrix} \quad \begin{bmatrix} 0 \\ -1.0 \\ 0 \end{bmatrix}$	$\{27.1 \quad 27.1 \quad 27.1\}$	$\beta_1^{0,2} = 1.0$
$W_2^{0,2} = \begin{bmatrix} -20.7 & 0 & 0 \\ 0 & -20.7 & 0 \\ 0 & 0 & -20.7 \end{bmatrix}$	$\begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix} \quad \begin{bmatrix} 0 \\ 0 \\ -1 \end{bmatrix} \quad \begin{bmatrix} 0 \\ -1 \\ 0 \end{bmatrix}$	$\{-20.7 \quad -20.7 \quad -20.7\}$	$\beta_2^{0,2} = 1.0$

Minkowski Tensors – Radius 1.1

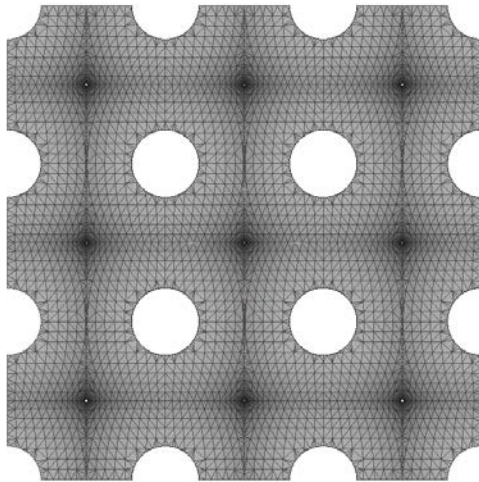
Minkowski Tensor	Eigenvectors	Eigenvalues	Anisotropy Index
$W_1^{0,2} = \begin{bmatrix} 33.1 & 0 & 0 \\ 0 & 33.1 & 0 \\ 0 & 0 & 33.1 \end{bmatrix}$	$\begin{bmatrix} -0.89 \\ 0.45 \\ 0 \end{bmatrix} \quad \begin{bmatrix} 0.45 \\ -0.89 \\ 0 \end{bmatrix} \quad \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$	$\{33.1 \quad 33.1 \quad 33.1\}$	$\beta_1^{0,2} = 1.0$

Asymmetric Parametric Pore – $R1 = 1.4$, $R2=1.3$

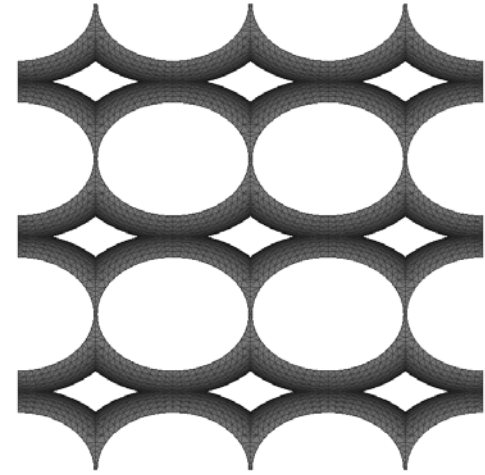
X-Y View



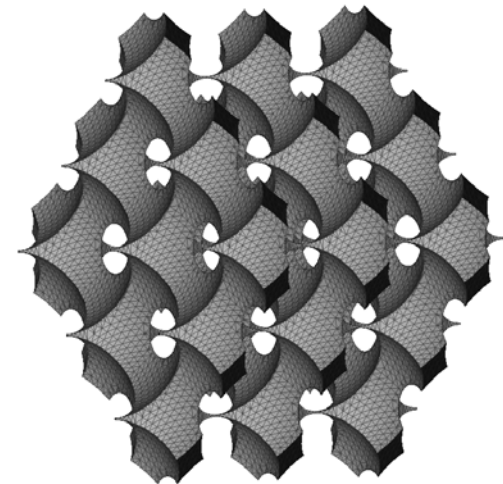
X-Z View



Y-Z View



3D View



Minkowski Tensors – R1 = 1.4, R2=1.3

Minkowski Tensor	Eigenvectors	Eigenvalues	Anisotropy Index
$W_1^{0,2} = \begin{bmatrix} 11.9 & 0 & 0 \\ 0 & 51.8 & 0 \\ 0 & 0 & 11.9 \end{bmatrix}$	$\begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix} \quad \begin{bmatrix} 0 \\ -1 \\ 0 \end{bmatrix} \quad \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$	$\{11.9 \quad 51.8 \quad 11.9\}$	$\beta_1^{0,2} = 0.23$
$W_2^{0,2} = \begin{bmatrix} -7.8 & 0 & 0 \\ 0 & -30.9 & 0 \\ 0 & 0 & -7.6 \end{bmatrix}$	$\begin{bmatrix} -1 \\ 0 \\ 0 \end{bmatrix} \quad \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix} \quad \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$	$\{-7.8 \quad -30.9 \quad -7.8\}$	$\beta_2^{0,2} = 0.25$