

Fluid Leakage across a Pressure Seal

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Mathematical Model → Simulation

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Simulation → Mathematical Model

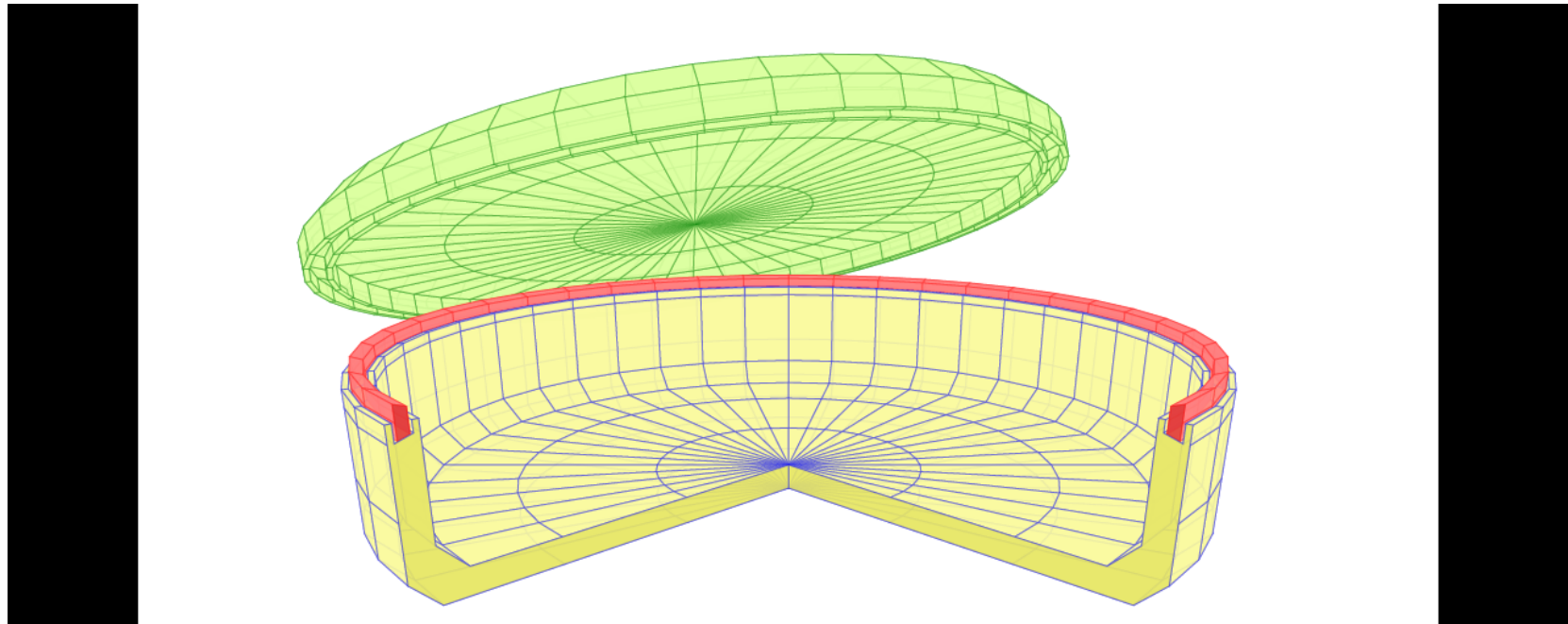
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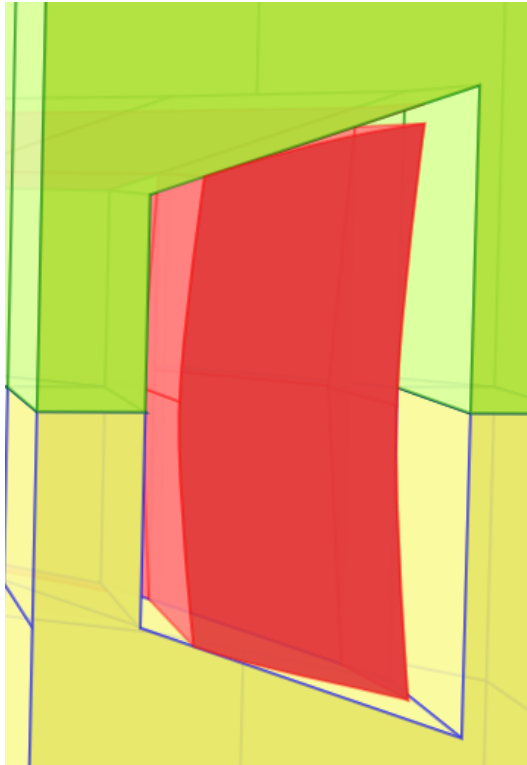
Multi-Scale Modeling (Homogenization)

- Mathematical theory of coordination between phenomena happening at different scales

Gasket Seals



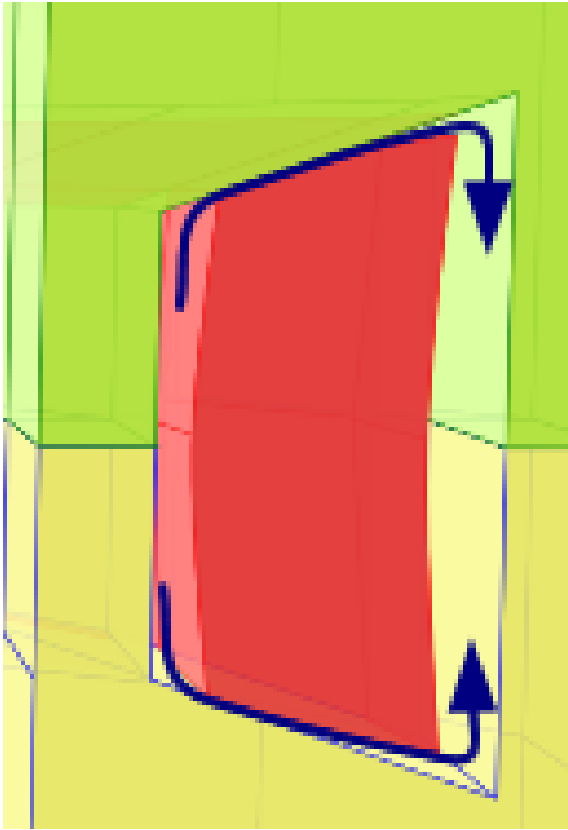
Gasket Seals



Leakage rate depends on:

- Geometries
- Materials
- Surface characteristics
- Clamping forces
- Fluid pressure

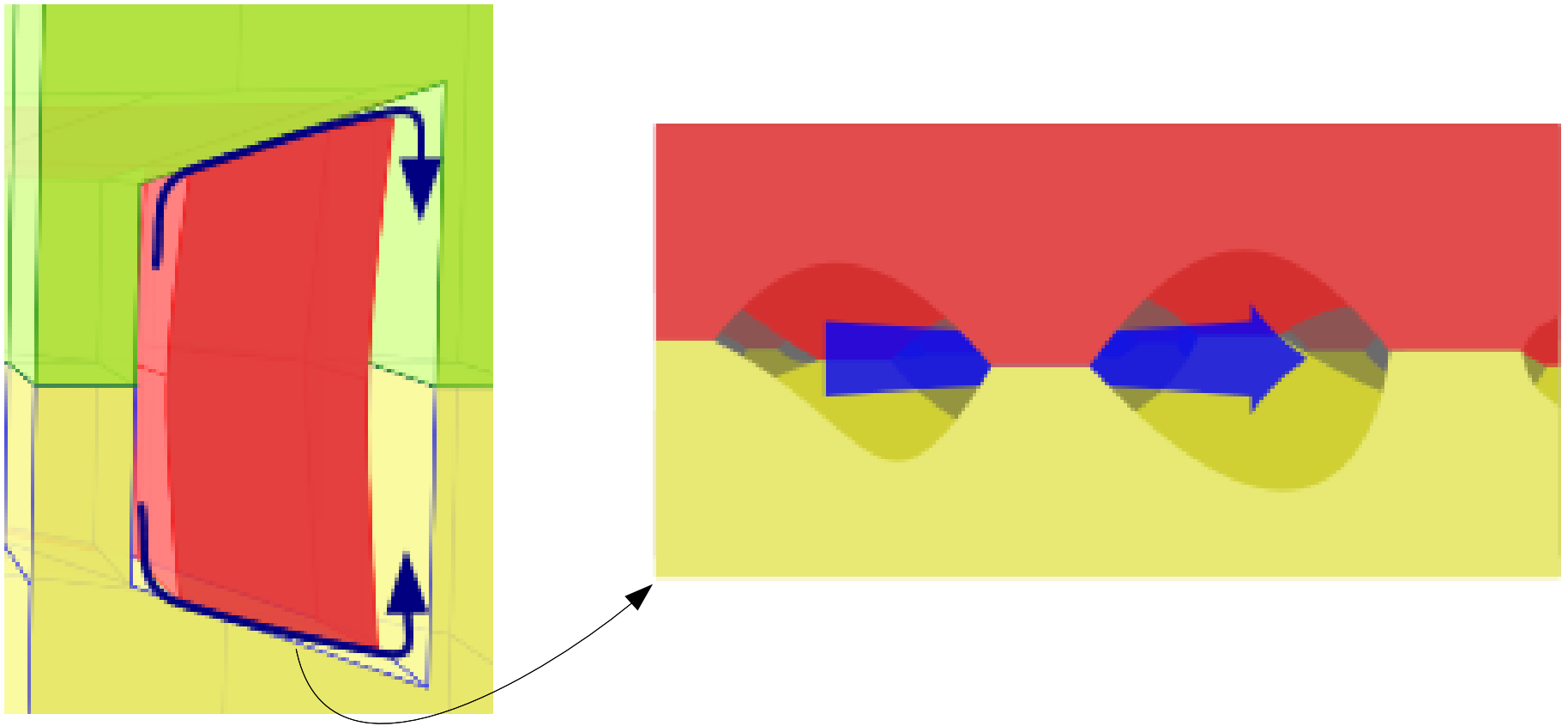
Fluid Leakage



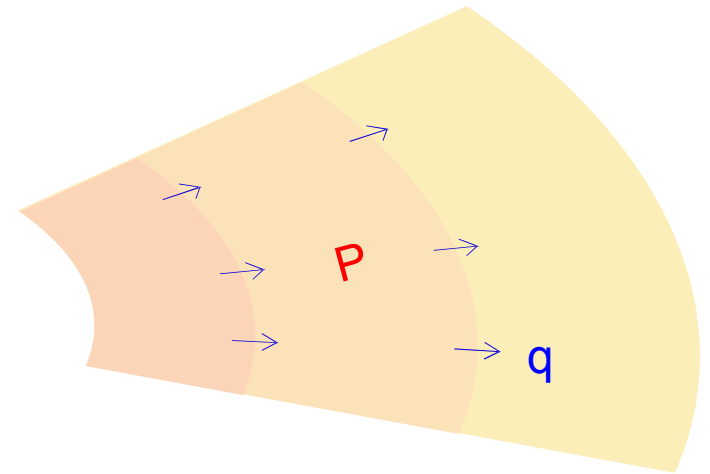
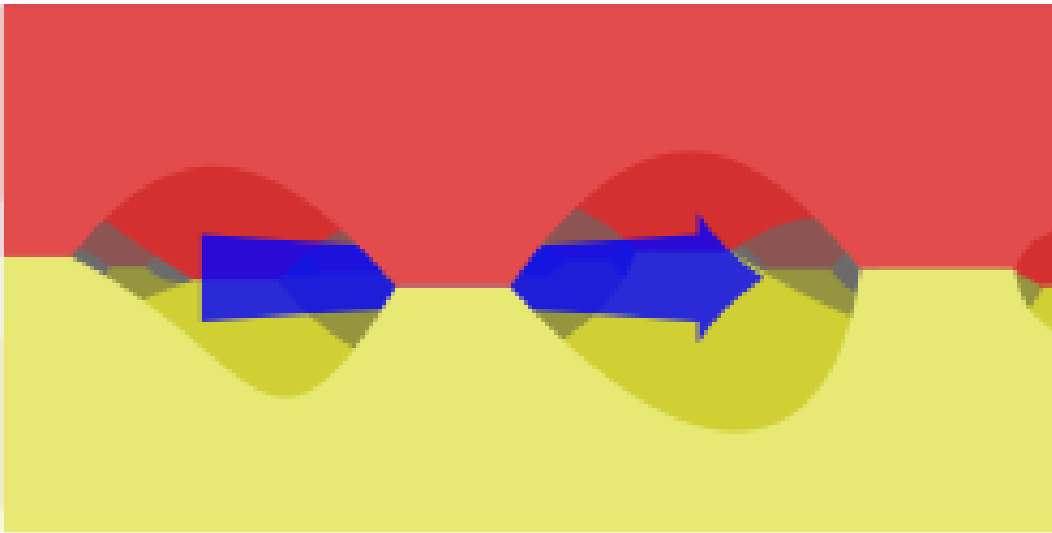
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Fluid Leakage



Homogenization

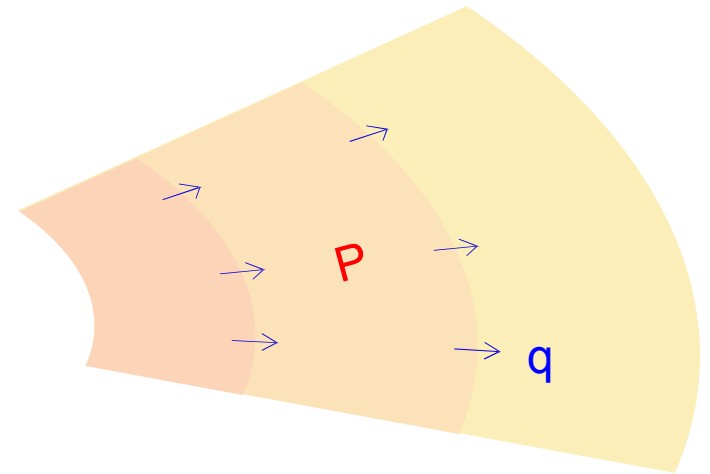


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Homogenization

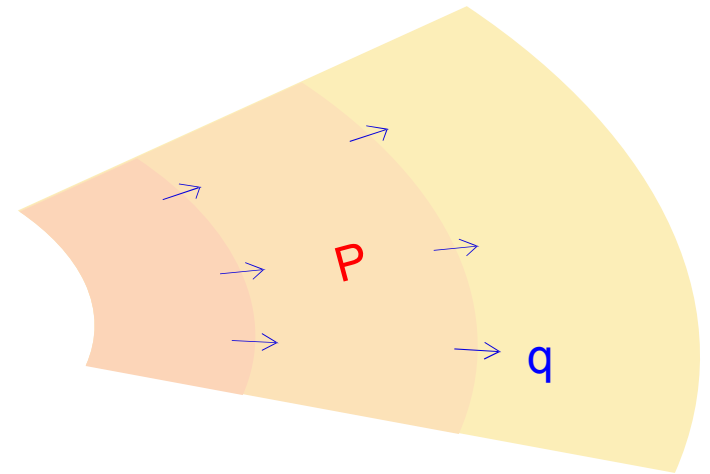
$$q = a \nabla P$$



Homogenization

$$q = a \nabla P$$

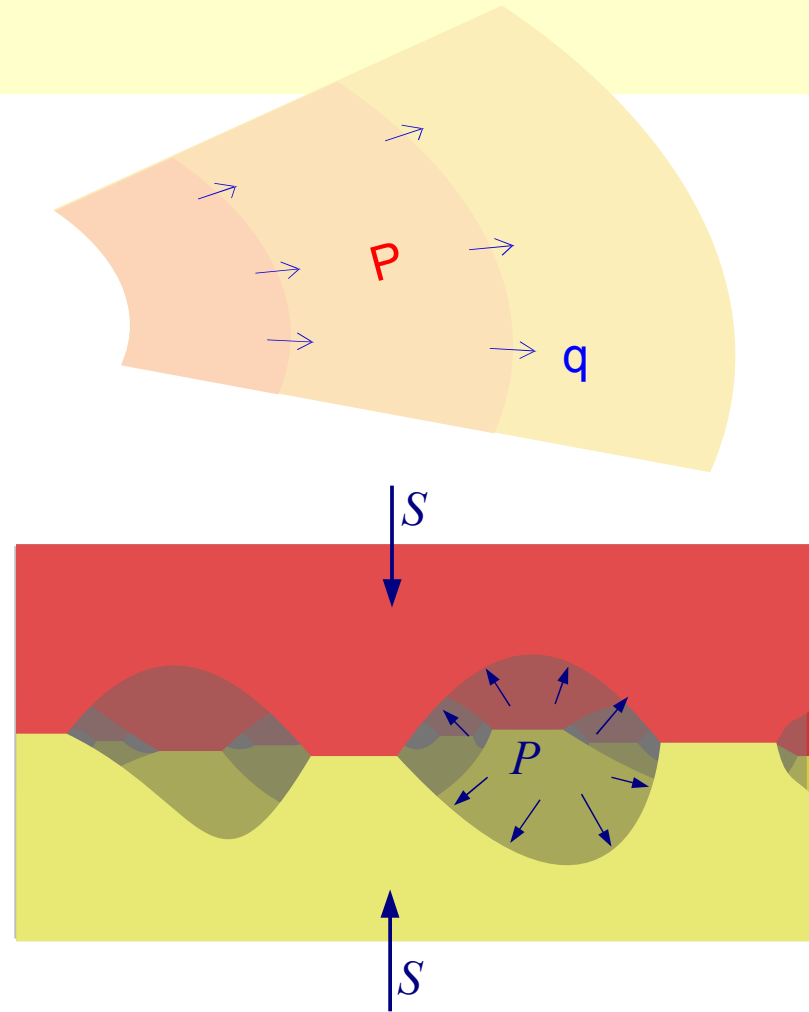
$$a = a(S, P, |\nabla P|)$$



Homogenization

$$q = a \nabla P$$

$$a = a(S, P, |\nabla P|)$$

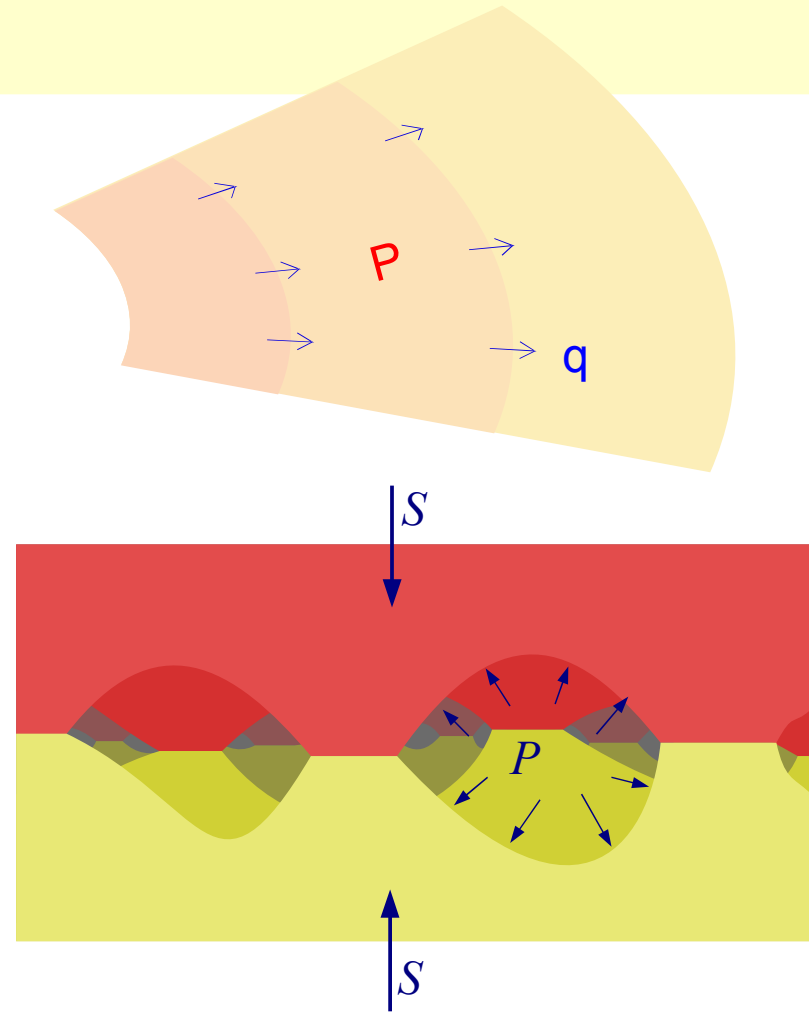


Geometric Result

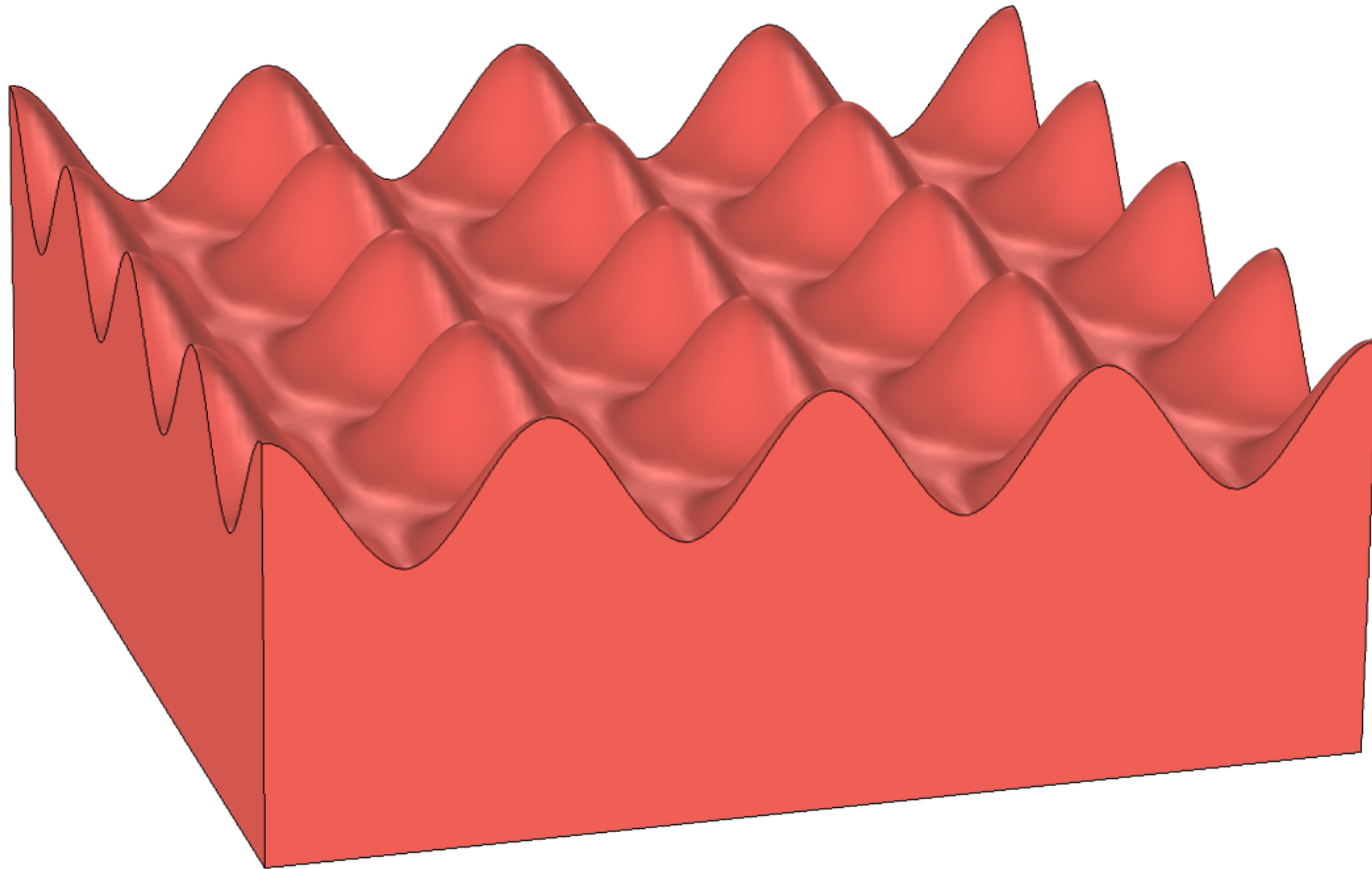
$$q = a \nabla P$$

$$a = a(S, P, |\nabla P|)$$

Geometry of
microcaverns depends
only on $S - P$



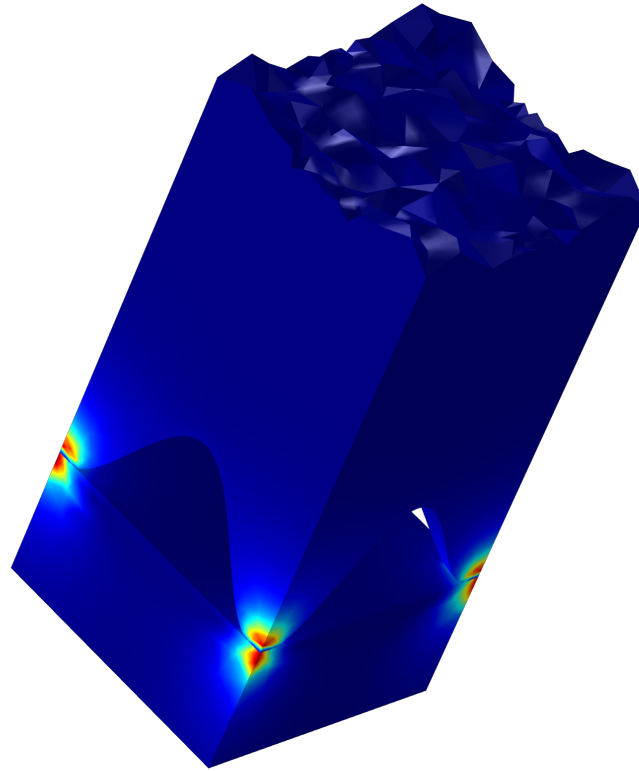
Idealization



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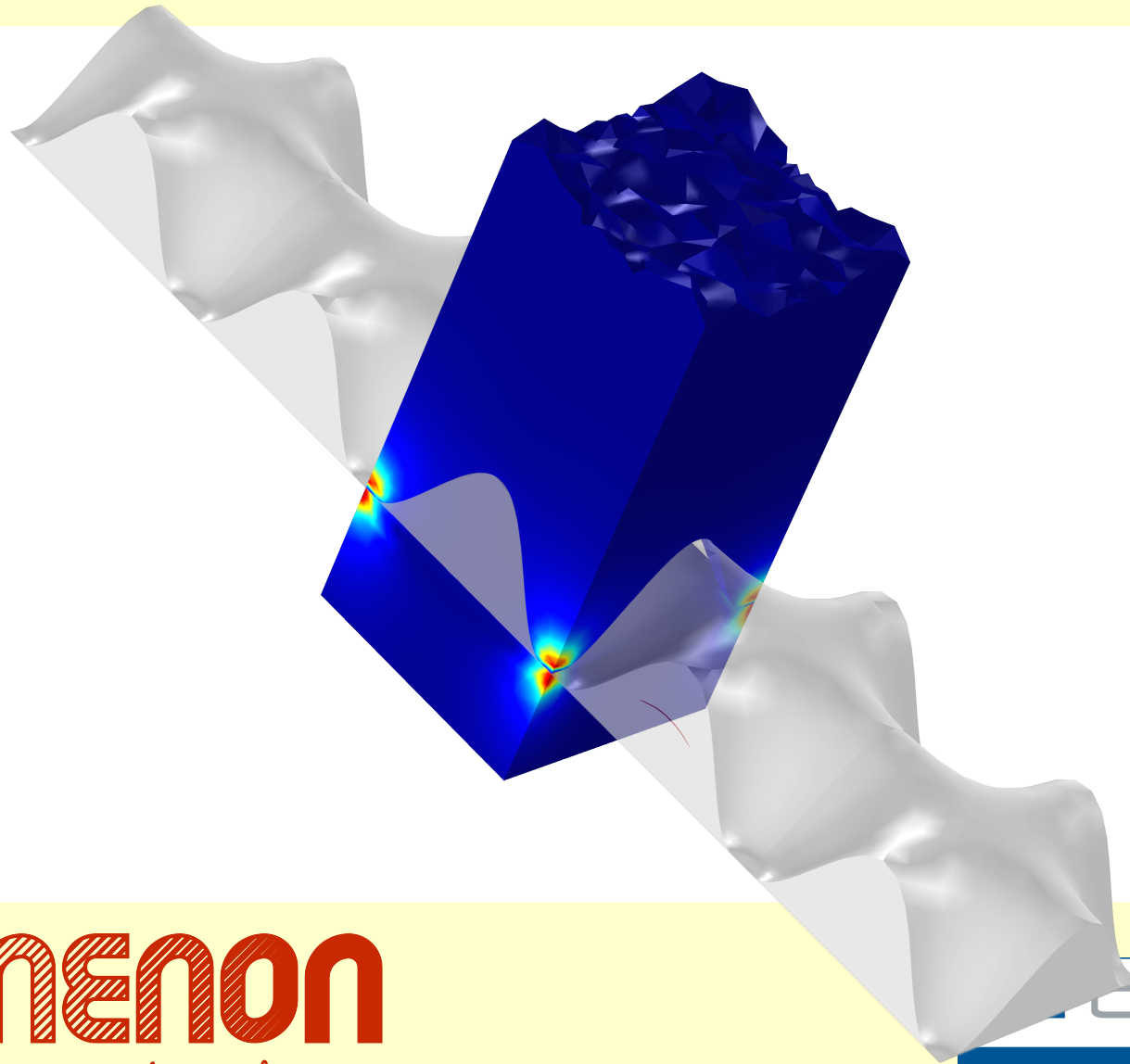
Mechanical Simulation



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Fluid Domain

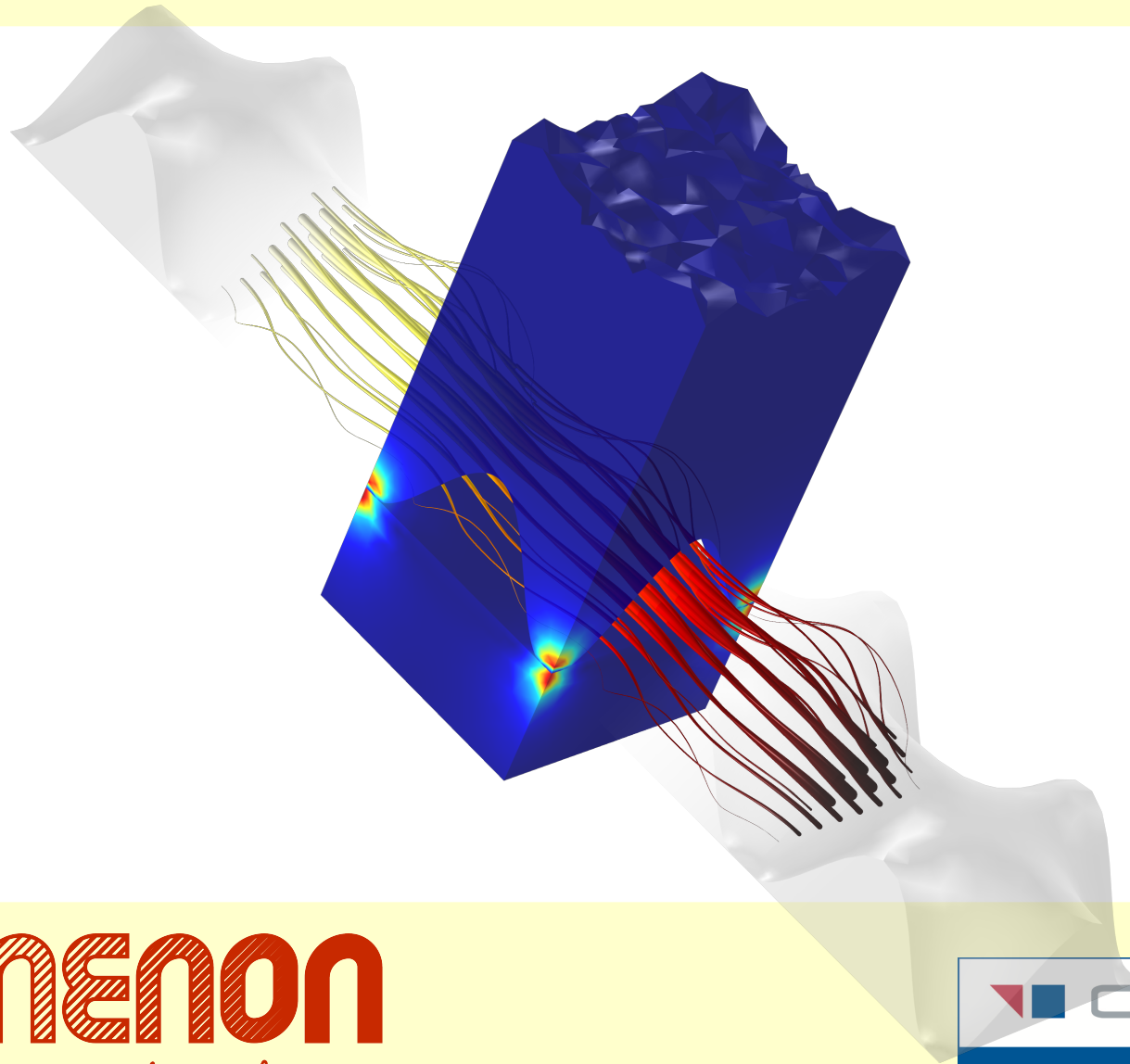


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Fluid Flow



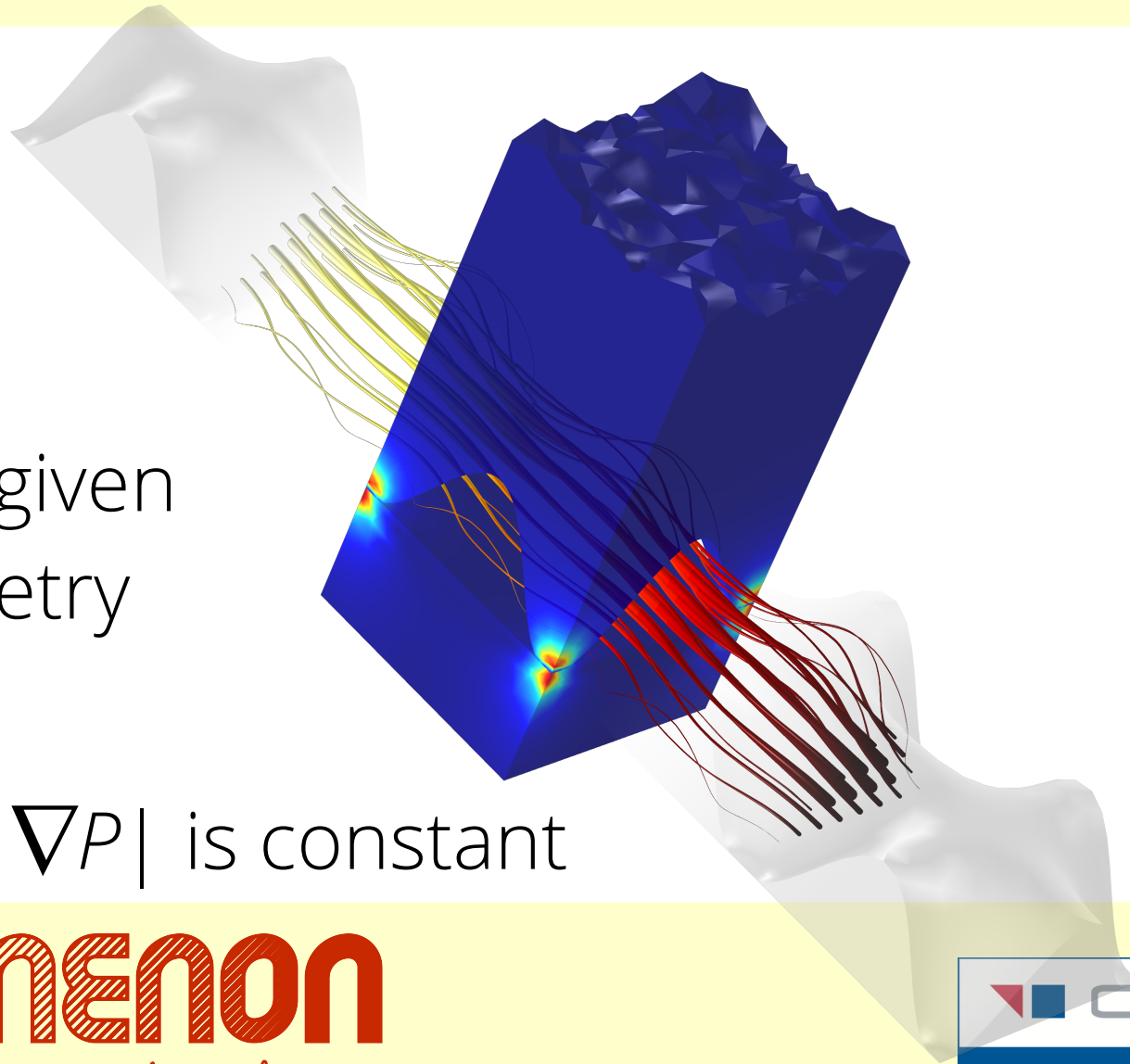
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Correlation

For a given geometry

- $q / P |\nabla P|$ is constant

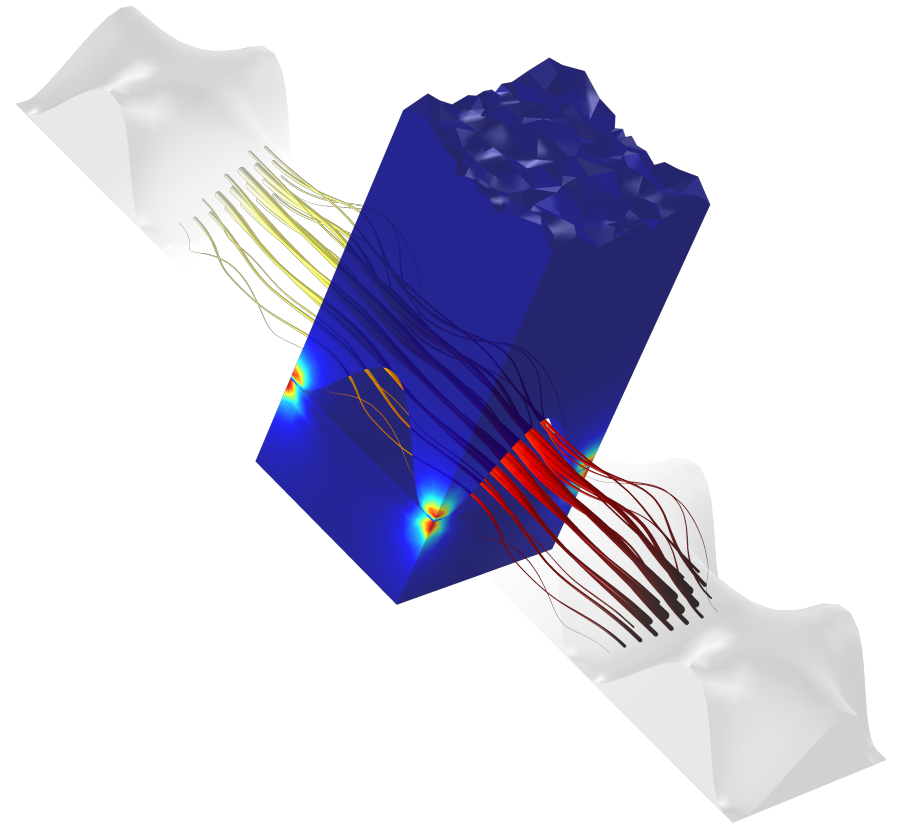


New Formula

- $q = f(S - P) P |\nabla P|$

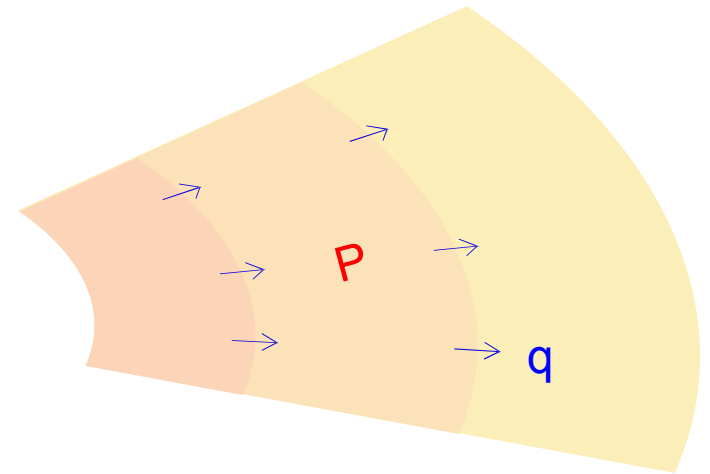
For a given geometry

- $q / P |\nabla P|$ is constant



New PDE!!!

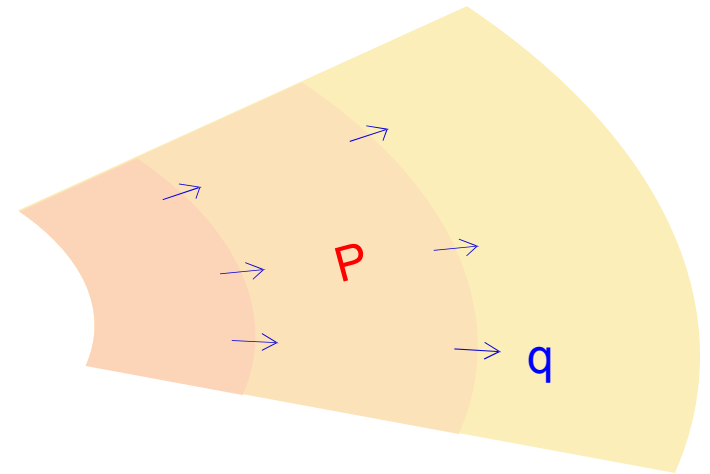
- $q = f(S - P) P |\nabla P|$



New PDE!!!

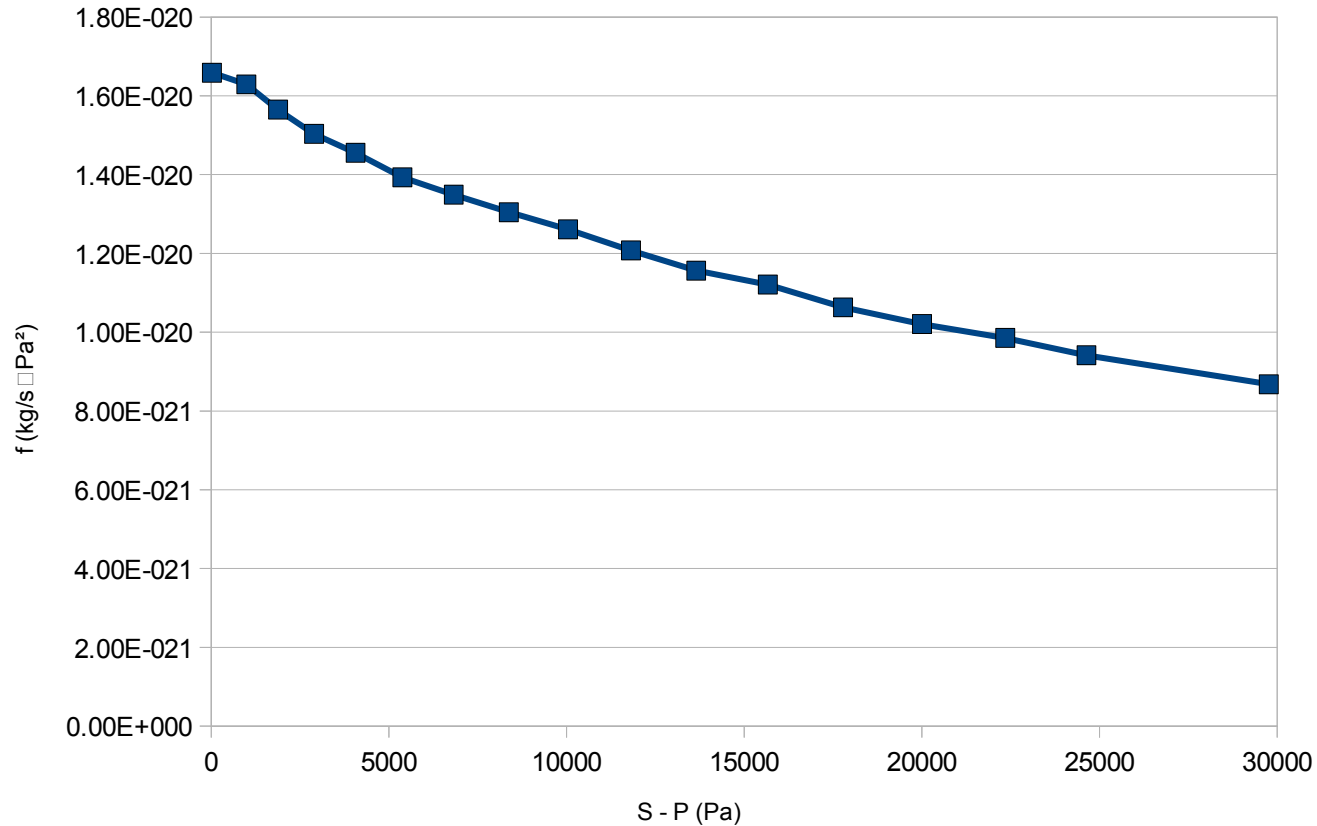
- $q = f(S - P) P |\nabla P|$

- $\nabla \cdot q = 0$



$$q = f(S - P) P |\nabla P|$$

Conductance parameter f as a function of S-P

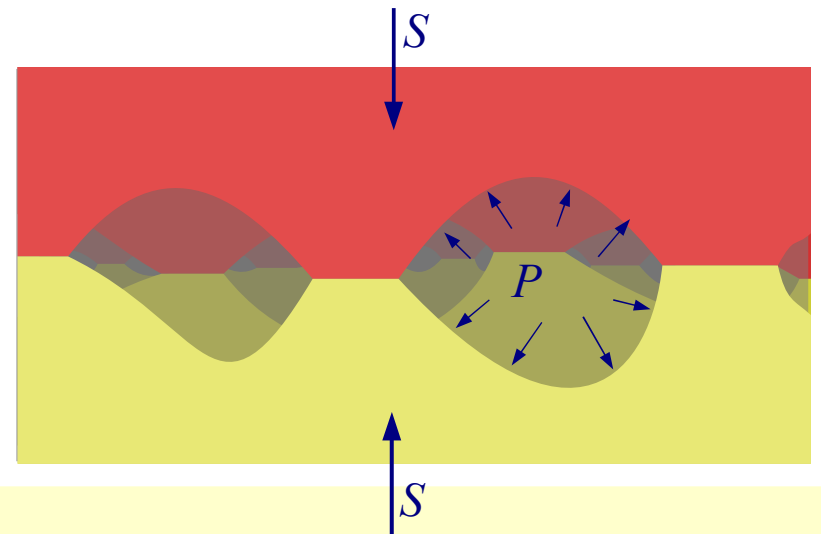
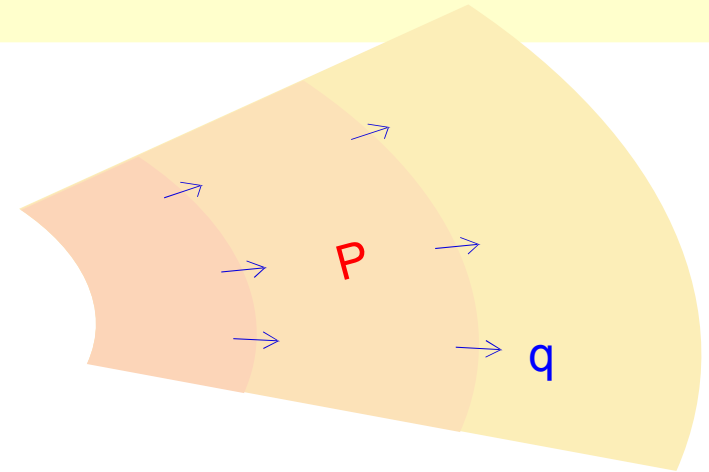


What we have achieved

$$q = a(S, P, |\nabla P|) \nabla P$$

- $q = f(S - P) P |\nabla P|$

$$\nabla \cdot q = 0$$



Thank you!

$$q = a(S, P, |\nabla P|) \nabla P$$

- $q = f(S - P) P |\nabla P|$

$$\nabla \cdot q = 0$$

