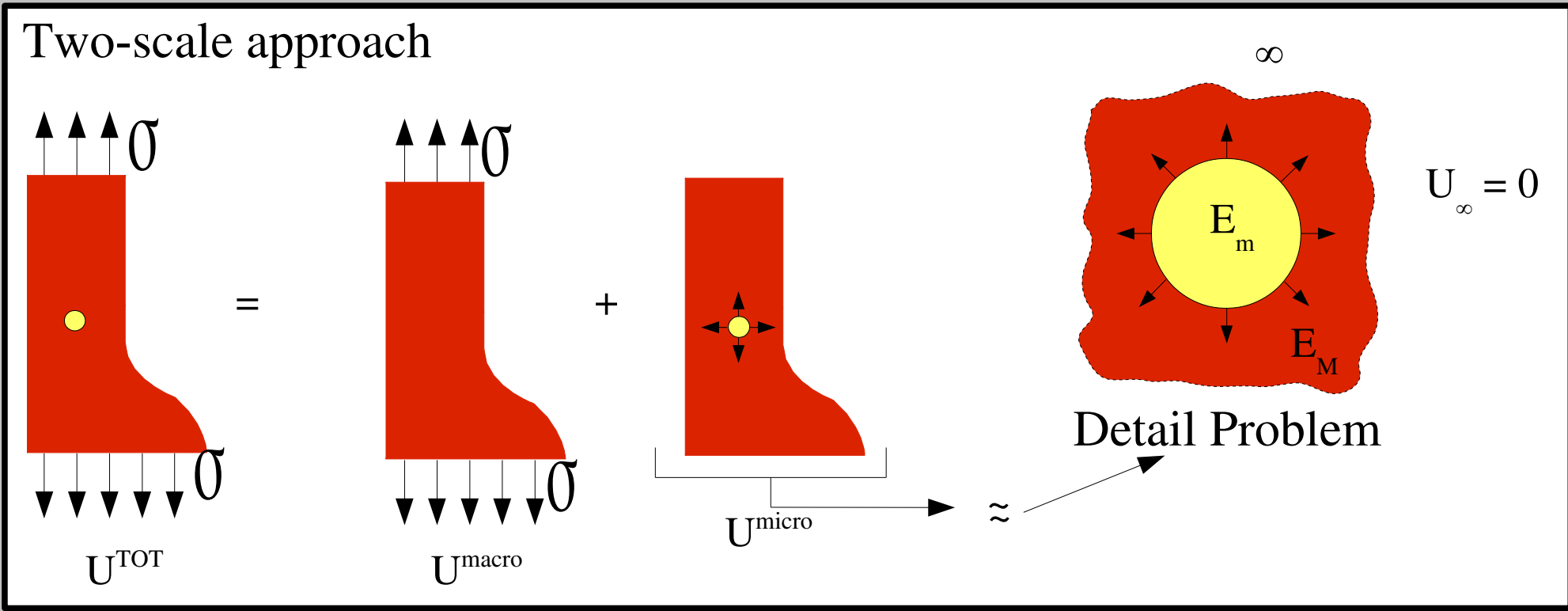


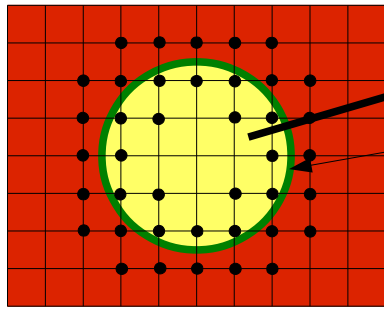
Aim : Taking into account the influence of a microscopic detail on a macroscopic structure under load using a two-scale approach



### Detail Problem

Features : embedded in an infinite media -> specific mapping  
 heterogeneous -> X-FEM & Level Set

## X-FEM (eXtended Finite Element Method)

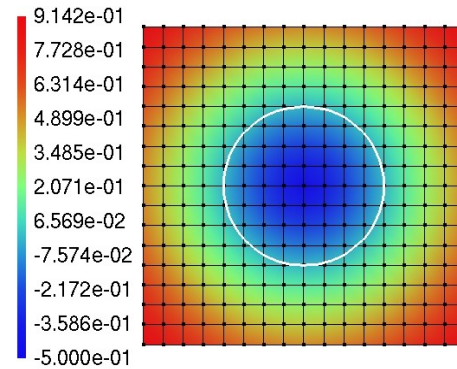


Inclusion  
Level Set  
+ classical node  
● enriched node

$$U^{FEM} = \sum_I U_I N_I(\mathbf{x})$$

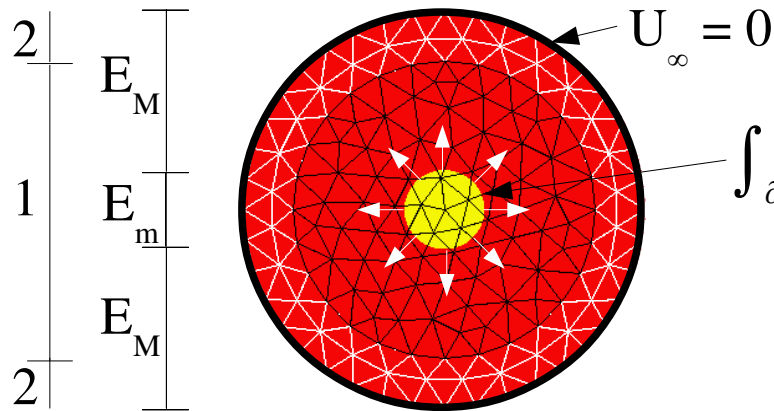
$$U^{X-FEM} = \sum_I U_I N_I(\mathbf{x}) + \overbrace{\sum_J a_J N_J(\mathbf{x}) F(\mathbf{x})}^{U^{enr}}$$

## Level Set



$$\Phi(\mathbf{x}) = \sum_I \Phi_I N_I(\mathbf{x})$$

$\Phi_I$  Distance to the interface at node I (with sign)



1 -> Lagrange Mapping  
2 -> Infinite Mapping

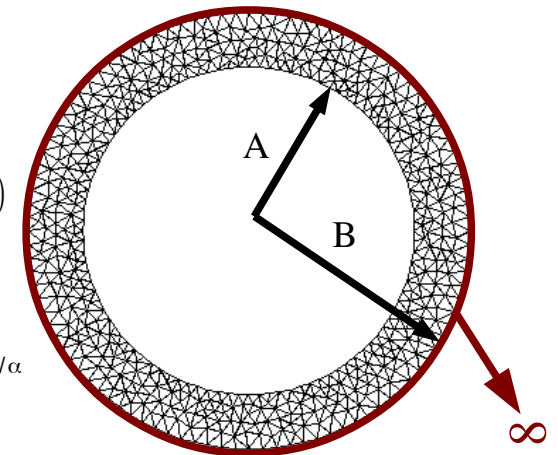
## Mapping

Nicolet & al (1994)

$$\vec{x} = \vec{X} (A(B-A)) / (R(B-R))$$

$$\vec{x} = (\vec{X} A/R) * (B-A/B-R)^{1/\alpha}$$

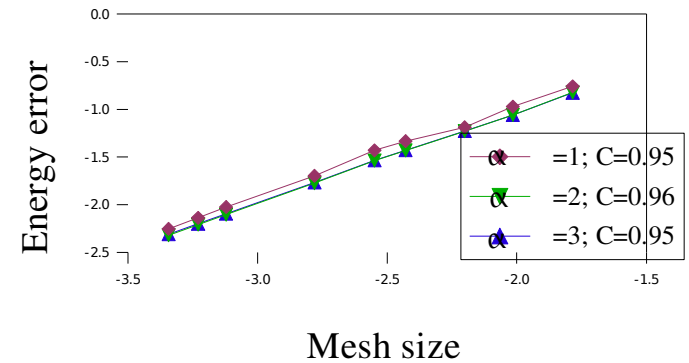
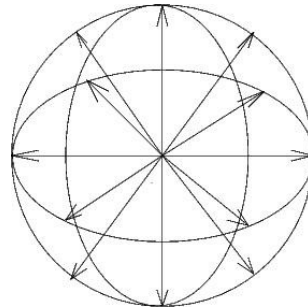
## Infinite Mapping



## Benchmark for the detail problem

Internal pressure in an infinite solid with a spherical cavity

(C : Convergence in term of energy norm)

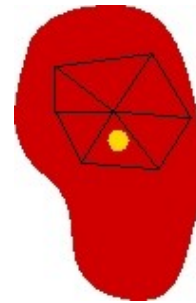


## Conclusion

- + Validation of the infinite mapping for cavity problems
- + Influence of  $\alpha$

## Outlooks on structural problem

### Enrichment strategy



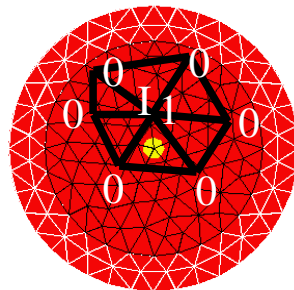
$$u^h = \sum_I U_I N_I + \sum_J a_J N_J F(U^{micro})$$

Definition of the enrichment fonction deduced from the displacement field of the detail problem

### Extended "homogenization"

Structural problem

Detail problem



$$K_{IJ} = \int_{\Omega} \epsilon_{ij}(\varphi_I) E_{ijkl} \epsilon_{kl}(\varphi_J) d\Omega$$

Substitution of the stiffness matrices

$$K_{IJ}^{hg} = \int_{\Omega} \epsilon_{ij}(\varphi_I + u^{micro}(\varphi_I)) E_{ijkl} \epsilon_{kl}(\varphi_J + u^{micro}(\varphi_J)) d\Omega$$