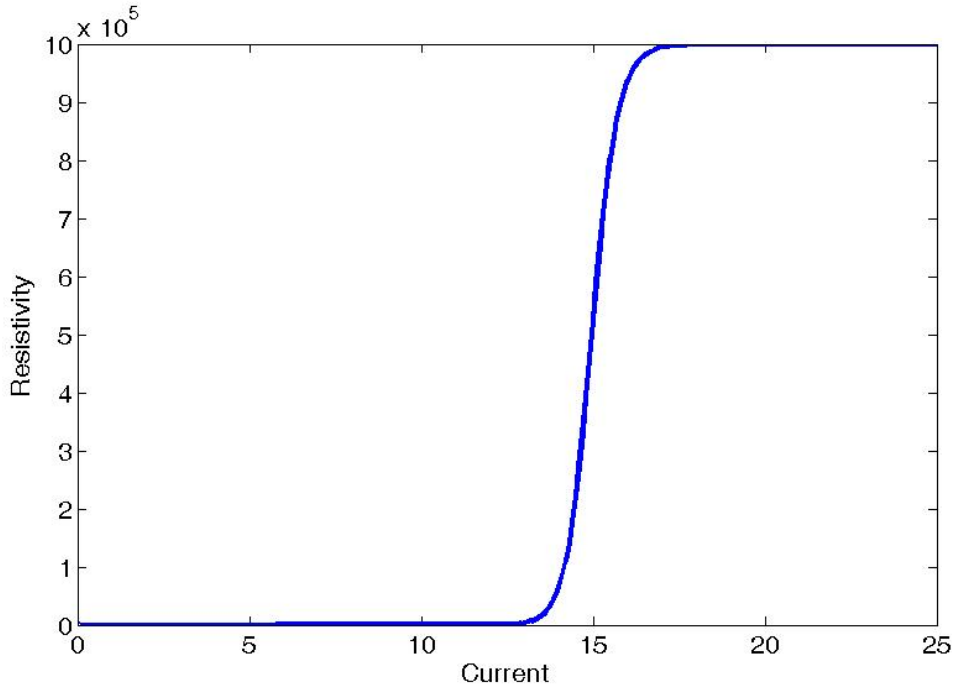
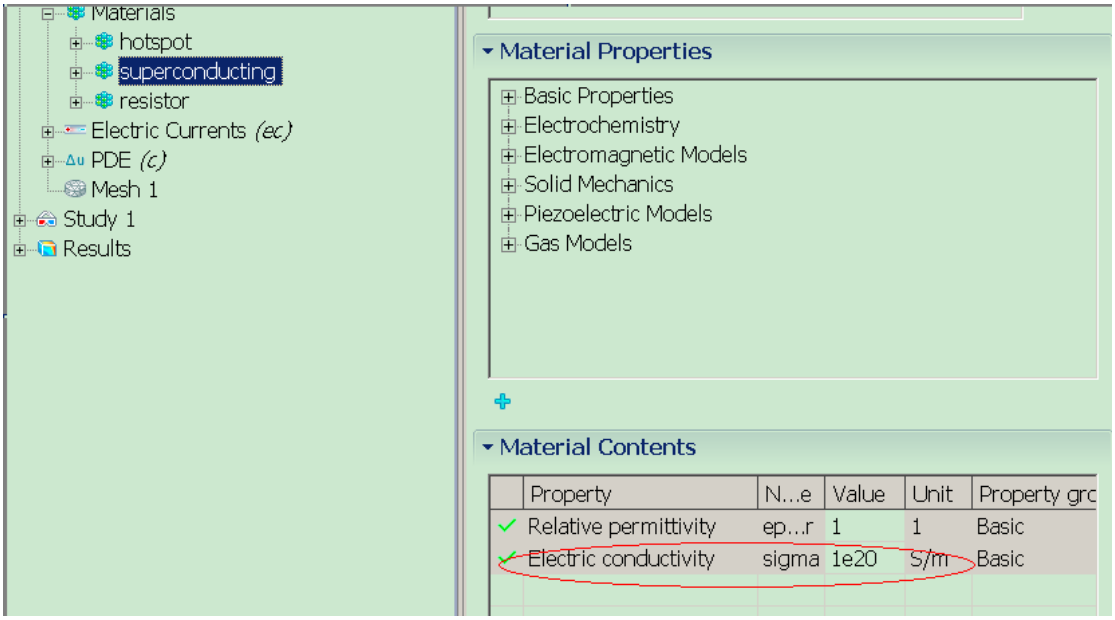
There are two models. Electrical current(ec) is used for solve the current distribution. PDE(c) is used for calculate the resistivity depended on current using analytic equation:

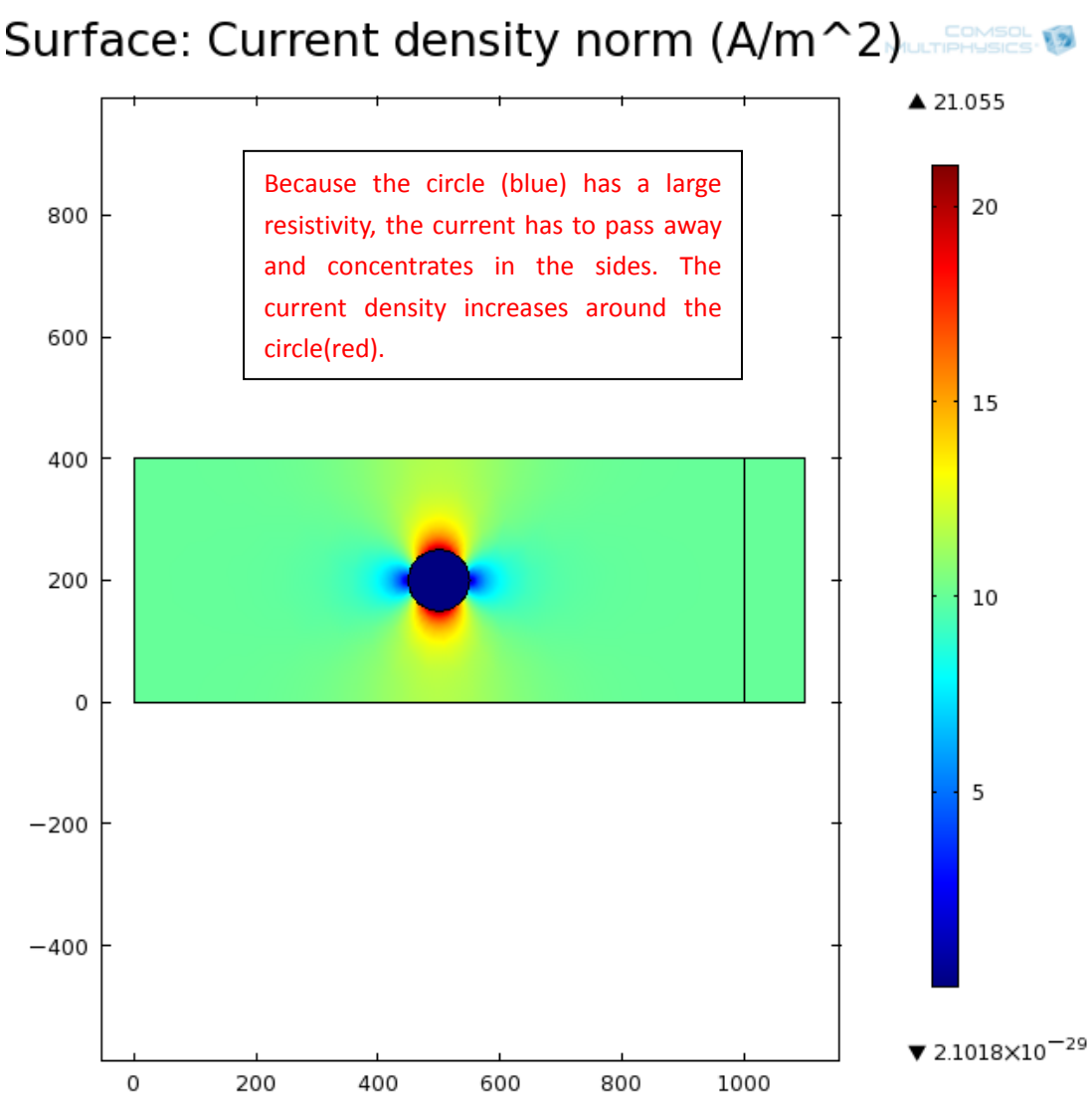
(E0*ec.normJ^40/super_jc^41)*rhon/(E0*ec.normJ^40/super_jc^41+rhon)+1e-10

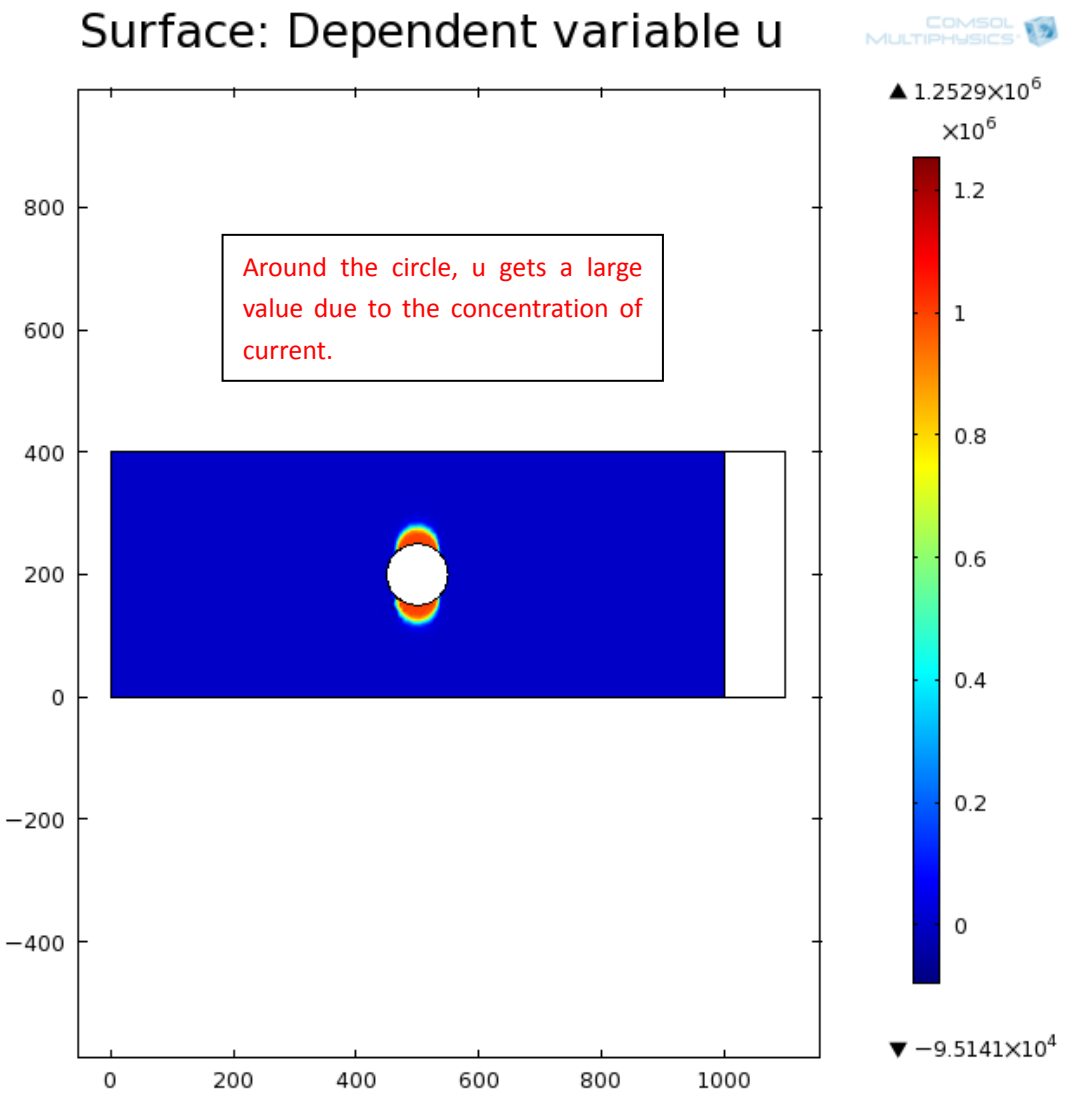
This equation can describe the change of resistivity with current shown in the following figure.



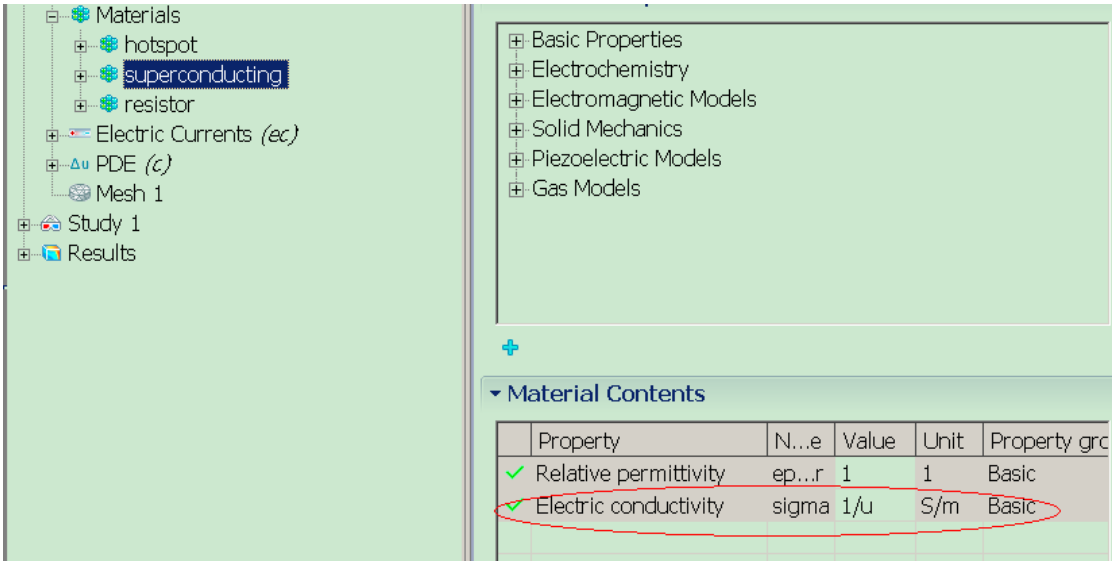
When I set the Electric conductivity of superconducting material 1e20 S/m, I can get the expected result. The solution of PDE which describes the resistivity shows that around the circle the resistivity is increased as the current is higher than super_jc which is used in the above equation to decide the level of rapid jumping of resistivity.

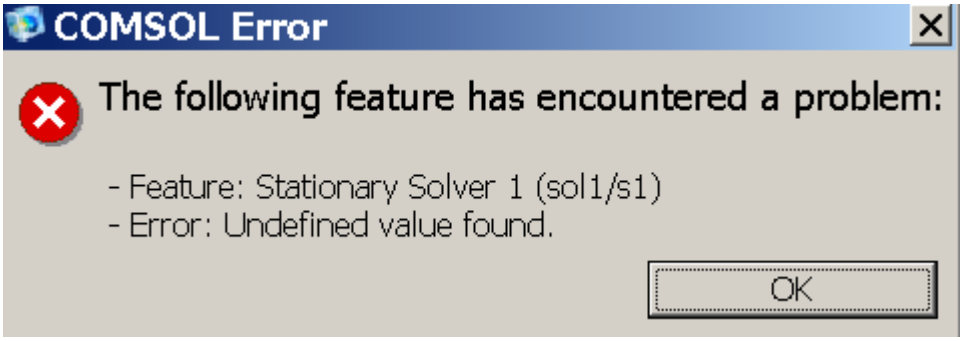



Surface: Current density norm (A/m^2)
Because the circle (blue) has a large resistivity, the current has to pass away and concentrates in the sides. The current density increases around the circle(red).
▲ 21.055
20
15
10
5
▼ 2.1018×10−29
800
600
400
200
0
−200
−400
0
200
400
600
800
1000



Then I set the Electric conductivity of superconducting material 1/u S/m and use segregated solver. An error jump.




COMSOL Error
The following feature has encountered a problem:
- Feature: Stationary Solver 1 (sol1/s1)
- Error: Undefined value found.
OK