Bridging 3D microscopic models to one-dimensional many body systems

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Realistic microscopic model —I→ 3D mean-field solution —II→ Effective 1D model —III→ Correlated Physics

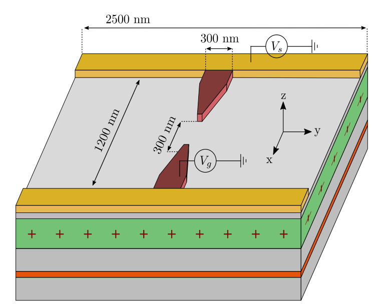
I

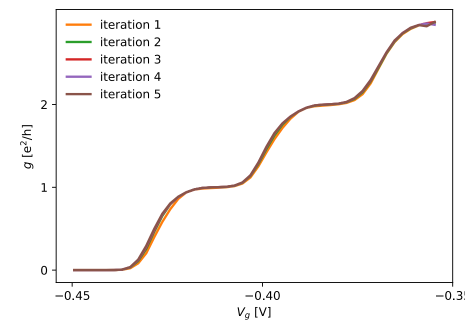
Schrödinger – Poisson self consistent problem
(Hartree approximation)

Capture mean field physics
with a microscopic parameter-less model.

Quantum hall physics at any B field value

P.Armagnat, X.Waintal, J. Phys. Matter: 3 (2020) 02LT01





P.Armagnat, A.Lacerda-Santos,
B.Rossignol, C.Groth, X.Waintal,
SciPost Phys, 7, 031 (2019)

II

Keep only the lowest energy propagating modes

III

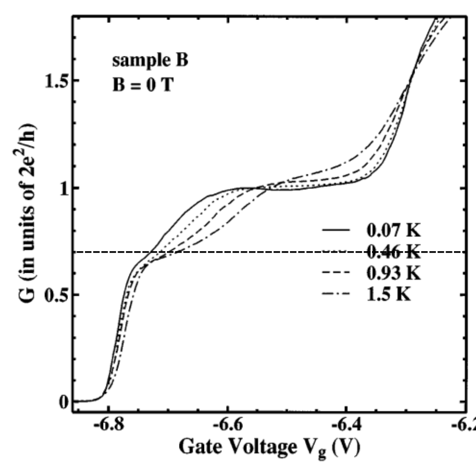
Quasi* – Quantum Monte Carlo

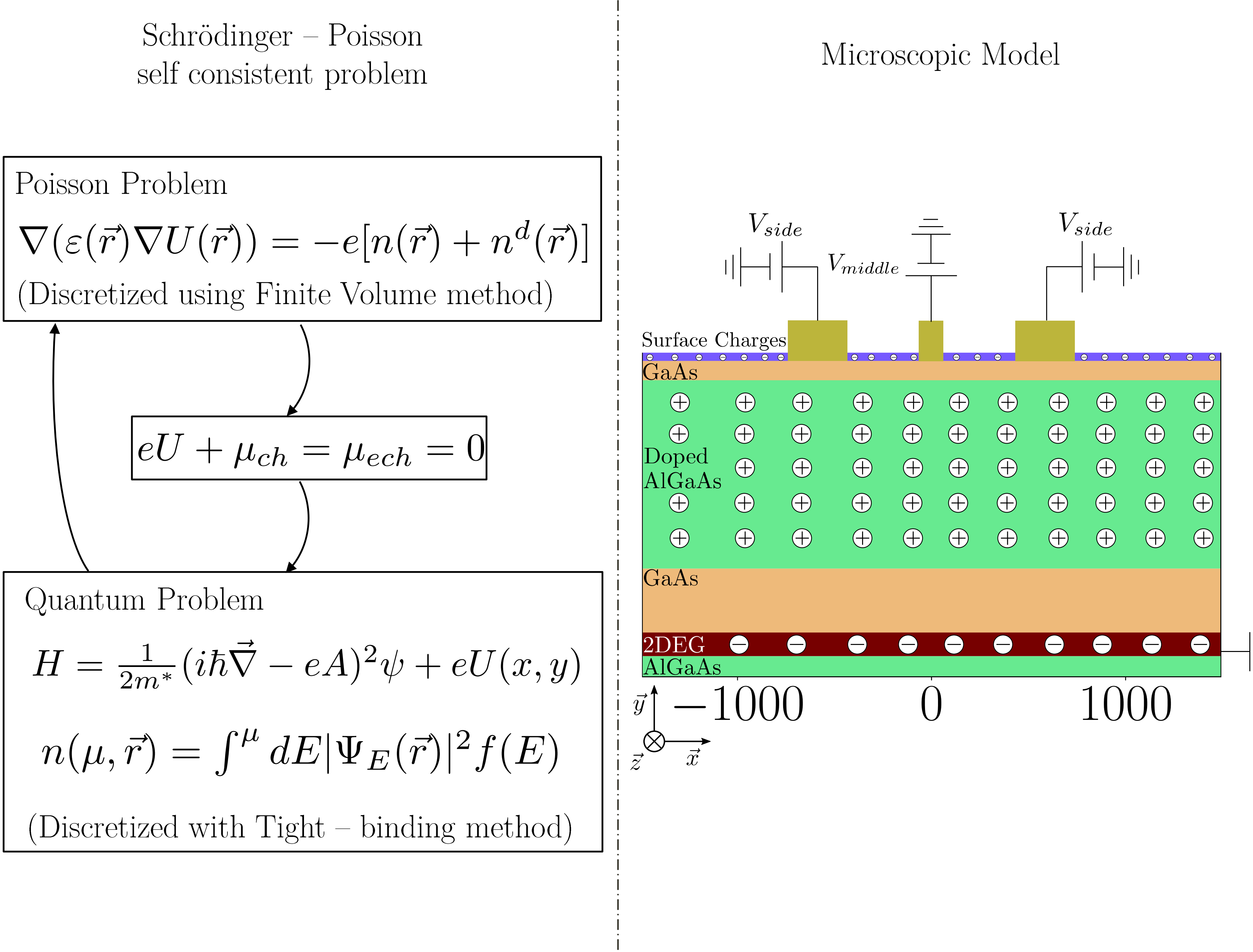
[*] M.Macek, P.T.Dumitrescu, C.Bertrand, B.Triggs, O.Parcollet, X.Waintal, arXiv:2002.12372 (2020)

C.Bertrand, S.Florens, O.Parcollet, X.Waintal PhysRev X 9.041008 (2019)

Understand the 0.7 Conductance anomaly

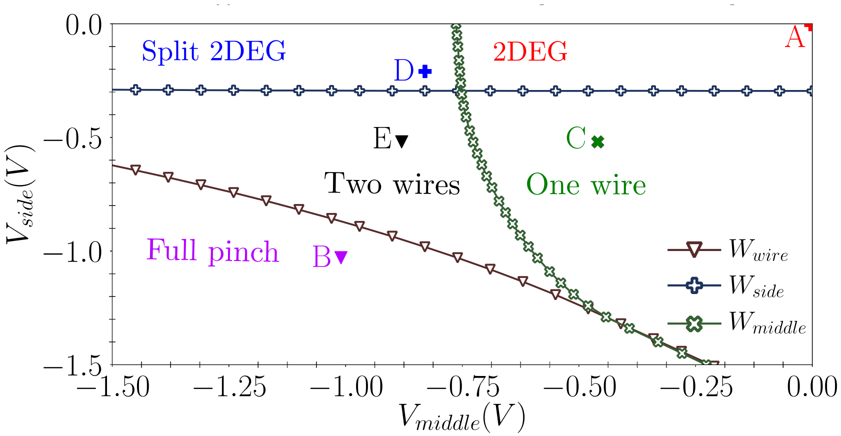
K.J.Thomas et al. Phys. Rev. Lett. 77. 135 (1996)

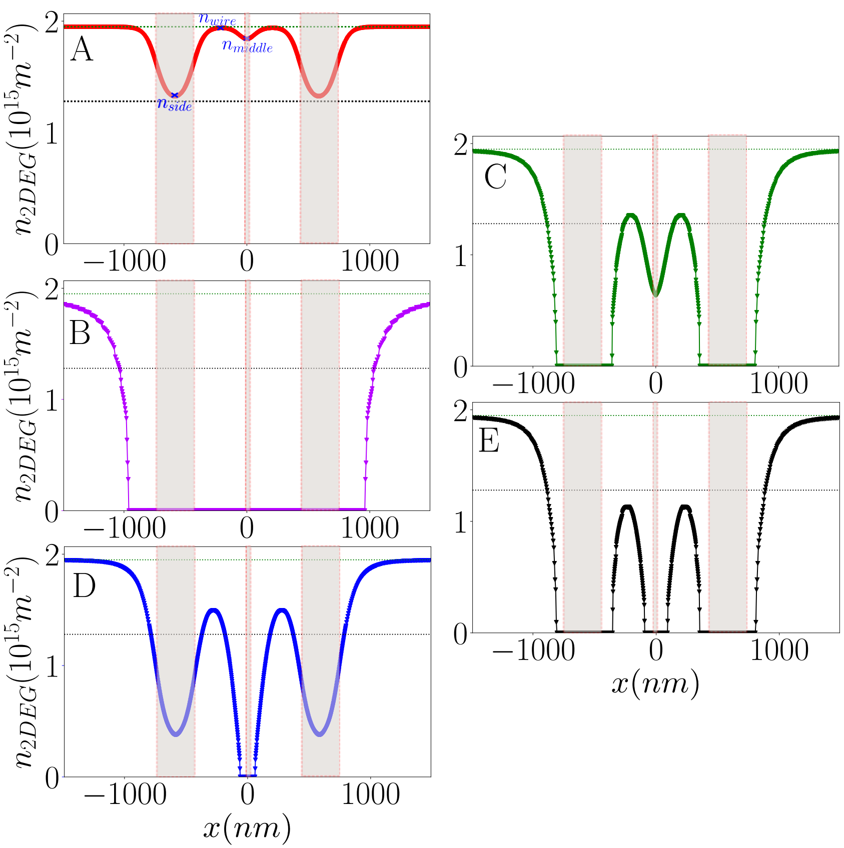




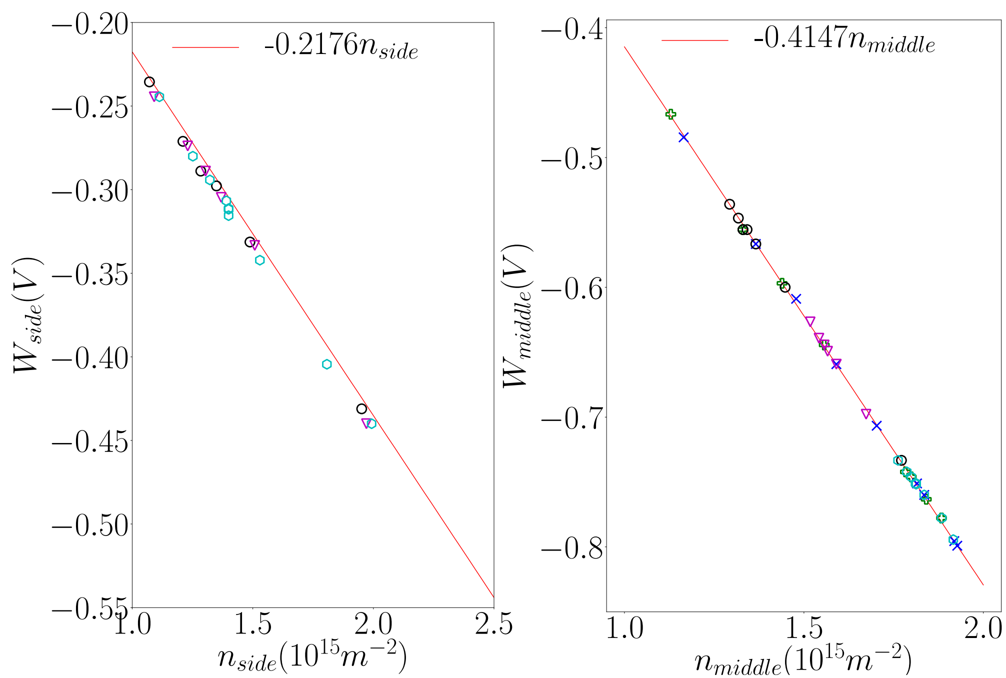
Schrödinger – Poisson
self consistent problem
Poisson Problem
$\nabla(\varepsilon(\vec{r})\nabla U(\vec{r})) = -e[n(\vec{r}) + n^d(\vec{r})]$
(Discretized using Finite Volume method)
$eU + \mu_{ch} = \mu_{ech} = 0$
Quantum Problem
$H = \frac{1}{2m^*}(i\hbar\vec{\nabla} - eA)^2\psi + eU(x,y)$
$n(\mu,\vec{r}) = \int^{\mu} dE|\Psi_E(\vec{r})|^2 f(E)$
(Discretized with Tight – binding method)
Microscopic Model
V_{side}
V_{middle}
V_{side}
Surface Charges
GaAs
Doped
AlGaAs
GaAs
2DEG
AlGaAs
-1000
0
1000
$\vec{y}$
$\vec{z}$
$\vec{x}$

Results I : Device phase diagram



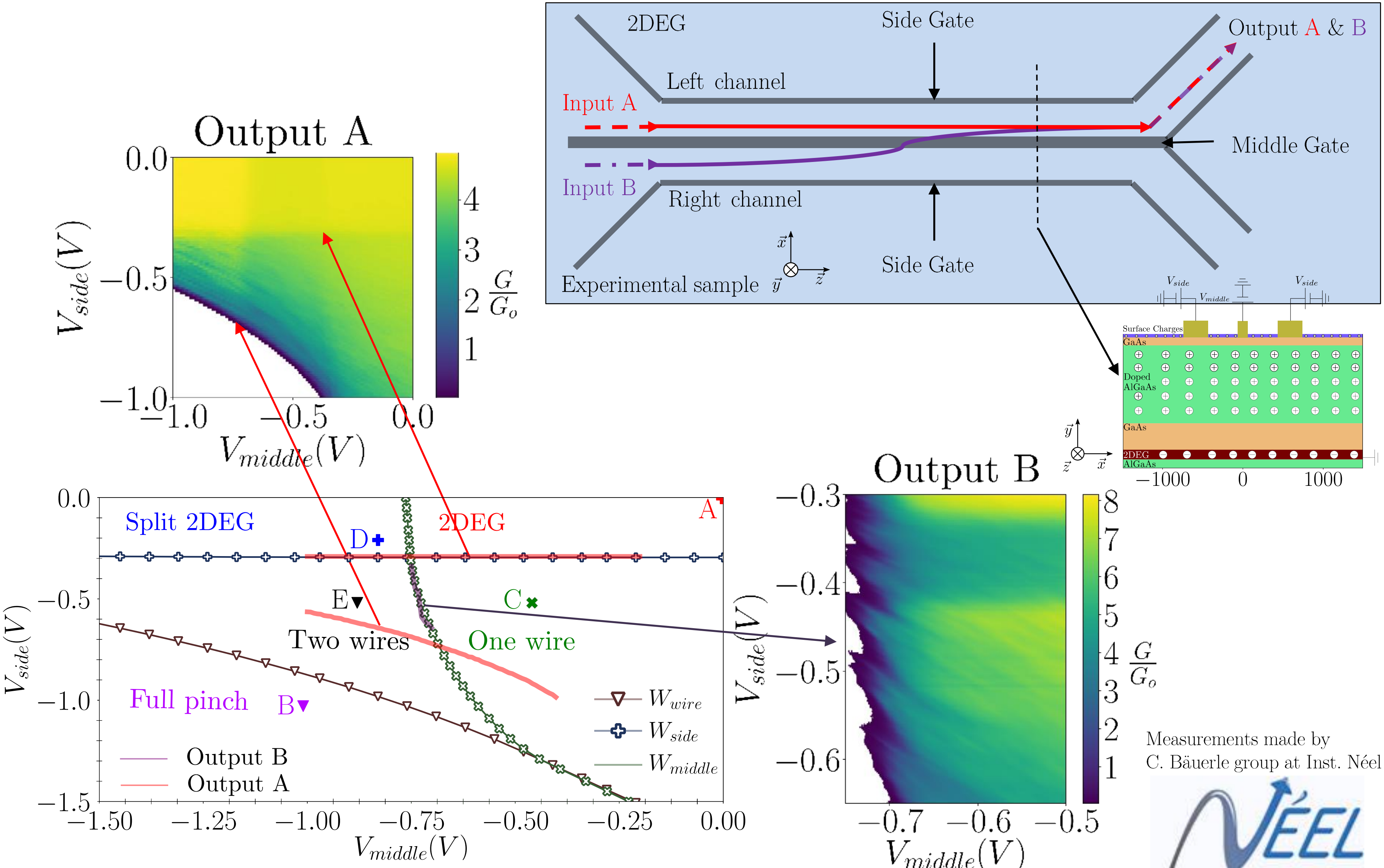


Results II : Extracting equilibrium density from phase diagram transition lines



W_{middle} and W_{side} transition lines → n_{middle} and n_{side} at equilibrium

Comparison with experimental data



Measurements made by
C. Bäuerle group at Inst. Néel