ELECTRON-ELECTRON INTERACTIONS, SCREENING AND POLARIZABILITY IN SEMICONDUCTOR AND GRAPHENE QDOTS

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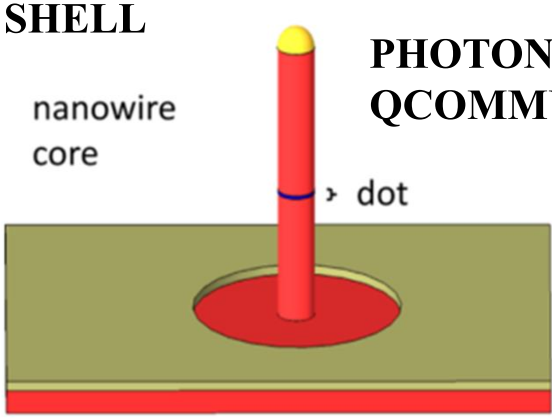
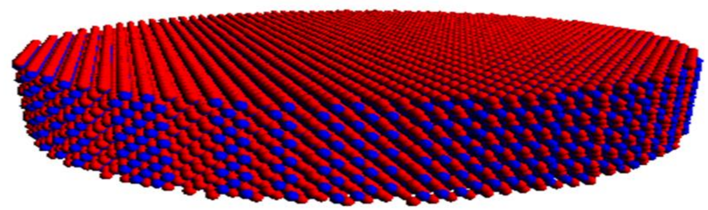
SEMICONDUCTOR AND GRAPHENE QUANTUM DOTS

InAs QD IN InP NWIRE
CONTROL OF HEIGHT, DIAMETER, SHELL

PHOTONS FOR QCOMMUNICATION



HgTe QDOTS:
QDOTS IN TOPOLOGICAL INSULATORS
ROBUST EDGE STATES-SENSORS



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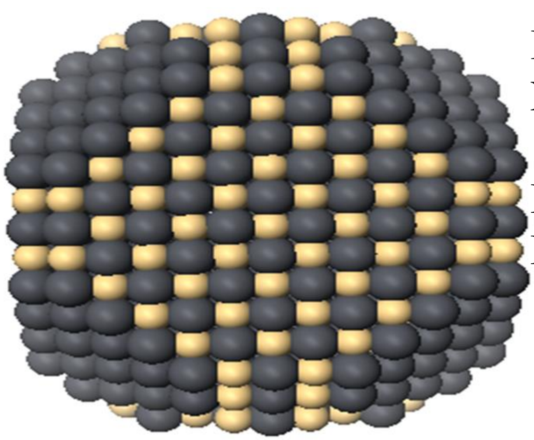
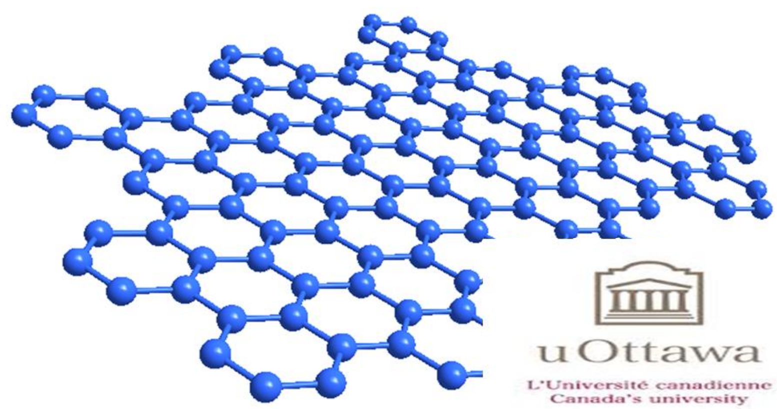


PbSe, CdSe Nanocrystals

BIO SENSORS
LED , PV

GRAPHENE QDOTS – ATOMIC CONTROL OF HEIGTH:



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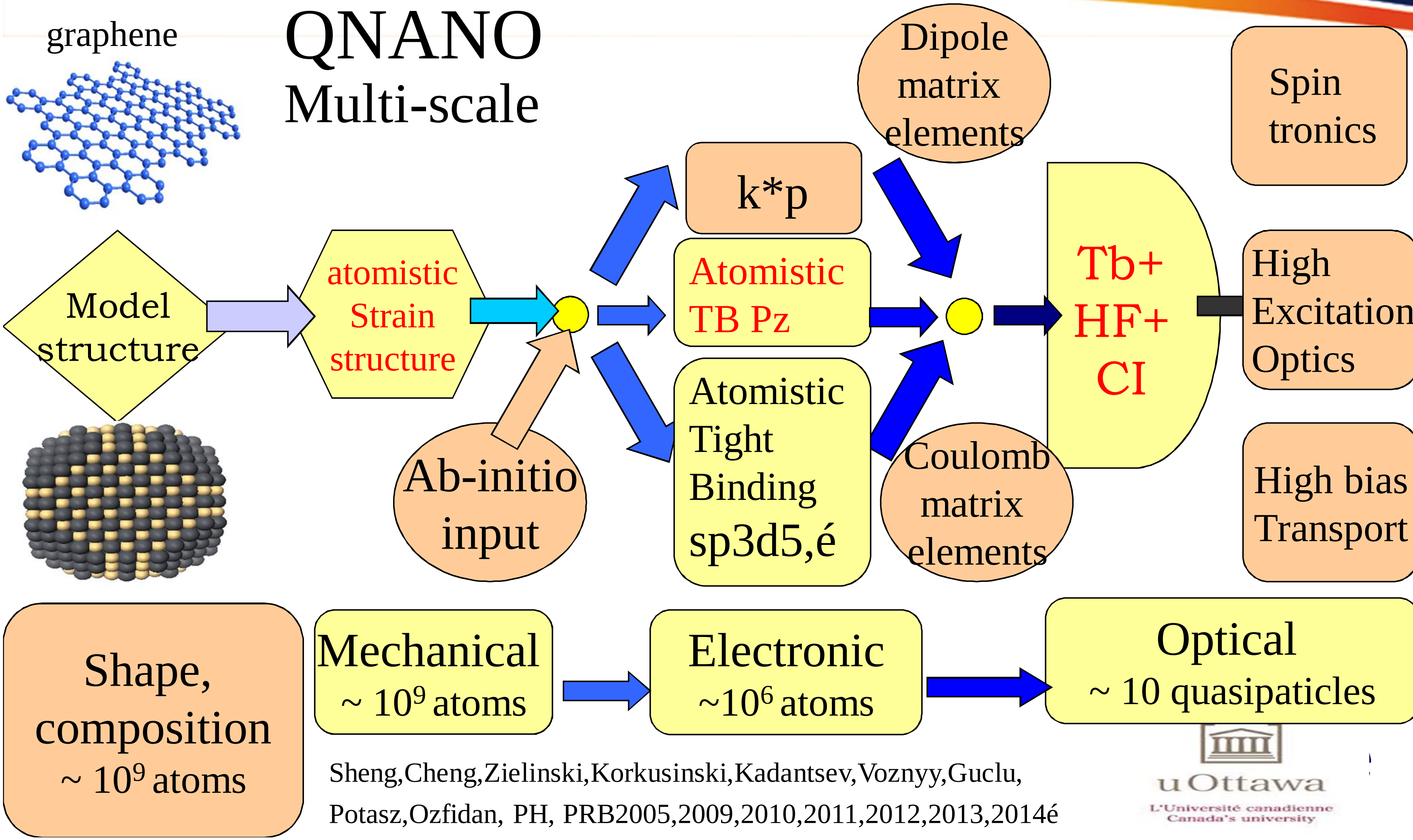
QNANO: MULTI-SCALE ATOMISTIC COMPUTATIONAL PLATFORM FOR SEMICONDUCTOR AND GRAPHENE QDOTS



Sheng,Cheng,Zielinski,Korkusinski,Kadantsev,Voznyy,Guclu,
Potasz,Ozfidan, PH, PRB2005,2009,2010,2011,2012,2013,2014é

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OUTLINE

INTRODUCTION

SCREENING IN QUANTUM DOTS (cRPA)

GRAPHENE QDOTS:

BANGAP, EXCITONS AND BIEXCITONS

SUBLATTICE ENGINEERING-MAGNETIC MOMENT AND E-E CORRELATIONS

2D ELECTRON GAS

ELECTRON-ELECTRON INTERACTIONS?

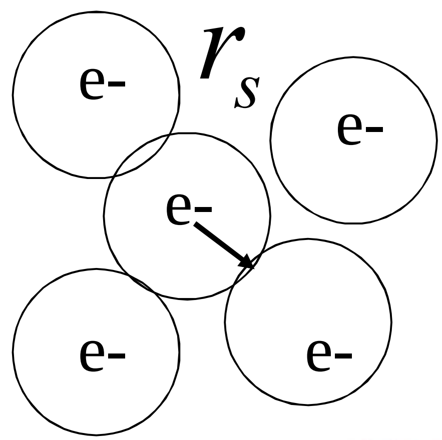
2DEG OF SCHRODINGER FERMIONS

$$H=\sum_i \frac{1}{2m}\left(-\frac{\partial^2}{\partial \vec{r}_i^{\,2}}\right)+\sum_{i<j}\frac{e^2}{\varepsilon\,|\vec{r}_i-\vec{r}_j|}$$

$$H=Ry\left(\sum_i \left(-\frac{\partial^2}{\partial \vec{r}_i^{\,2}}\right)+\sum_{i<j}\frac{2}{|\vec{r}_i-\vec{r}_j|}\right)$$

$$H=\left(\sum_i \frac{1}{r_s^2}\left(-\frac{\partial^2}{\partial \vec{r}_i^{\,2}}\right)+\frac{1}{r_s}\sum_{i<j}\frac{2}{|\vec{r}_i-\vec{r}_j|}\right)$$

$$H=\frac{1}{r_s^2}\left(\sum_i \left(-\frac{\partial^2}{\partial \vec{r}_i^{\,2}}\right)+r_s\sum_{i<j}\frac{2}{|\vec{r}_i-\vec{r}_j|}\right)$$



PERTURBATION THEORY IN RS

2D ELECTRON GAS

ELECTRON-ELECTRON INTERACTIONS

2DEG OF SCHRODINGER FERMIONS-PERTURBATION THEORY

$$E_k = \xi_k^e + \Sigma_e(k, \xi_k^e)$$

$$\mathrm{Im}\Sigma_e(k,\xi_k^e) = \int_0^{\infty} \frac{d\, q q^{\Omega}}{2\pi} \int_0^{(k,q)} \frac{d\omega}{2\pi} \frac{\{1-f(\xi_k^e-\omega)\}\{-2\,\mathrm{Im} W_{ee}(q,\omega)\}}{2\pi\sqrt{[\omega-\Omega_-(k,q)][\Omega_+(k,q)-\omega]}}$$

SCREENED INTERACTION W

RPA: $\mathrm{Im}(W(q,\omega)) = \mathrm{Im}\{W^0/(1-W^0\Pi^0)\}$

LOCAL FIELD CORRECTION $W_0 \Rightarrow W_0(1-G)$

VNS: $\mathrm{Im}(W(q,\omega))$

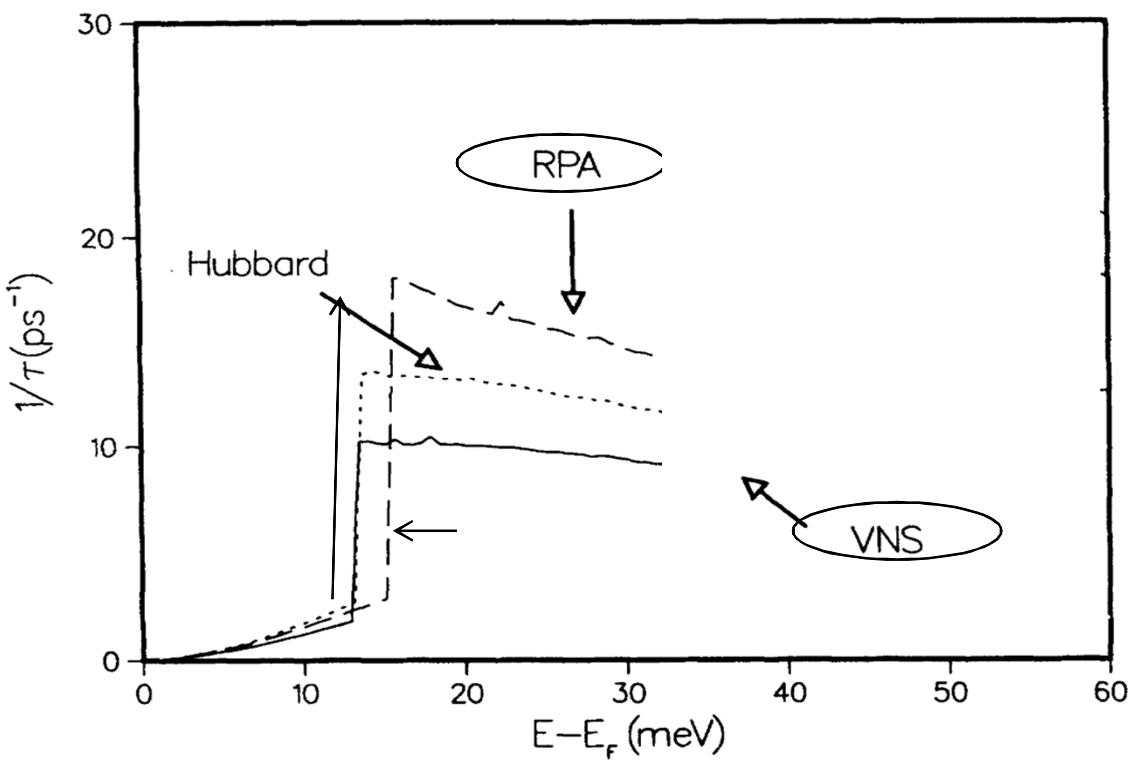
$$= \mathrm{Im}\{W^0(1-G)/[1-W^0(1-G)\Pi^0]\}$$

2D ELECTRON GAS

ELECTRON-ELECTRON INTERACTIONS

2DEG OF SCHRODINGER FERMIONS-PERTURBATION THEORY

$$E_k = \xi_k^e + \Sigma_e(k, \xi_k^e)$$



Local field G

Renormalization of Plasmon energy

Renormalization of el Plasmon coupling

WITH JEFF YOUNG
PRB1994

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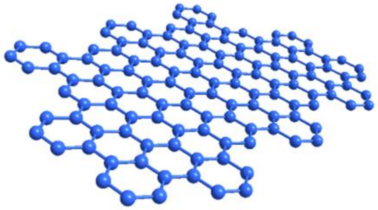
2D ELECTRON GAS

ELECTRON-ELECTRON INTERACTIONS?

2DEG OF SCHRODINGER FERMIONS

$$H = \sum_i \frac{1}{2m}\left(-\frac{\partial^2}{\partial \vec{r}_i^{\,2}}\right) + V_{lattice}(\vec{r}_i) + \sum_{i<j} \frac{e^2}{\varepsilon\,|\vec{r}_i - \vec{r}_j|}$$

Lattice dominates



K*p

$$H = \sum_i v_F \vec{\sigma}\left(-\frac{\partial}{\partial \vec{r}_i}\right) + \sum_{i<j} \frac{e^2}{\varepsilon\,|\vec{r}_i - \vec{r}_j|}$$

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2DEG OF DIRAC FERMIONS

ELECTRON-ELECTRON INTERACTIONS?

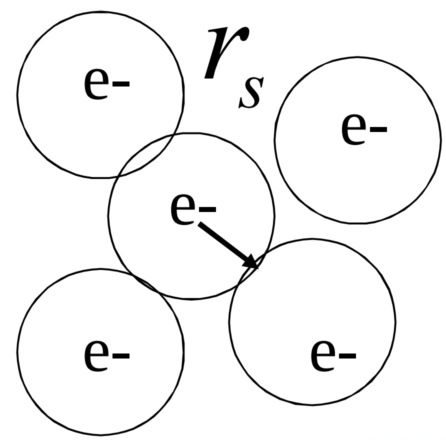
2DEG OF DIRAC FERMIONS

Kotov,Castro-Neto,
Uchoa,Vozmedano,
Guinea,DasSarmaé é .

$$H=\sum_i v_F \vec{\sigma}\left(-\frac{\partial}{\partial \vec{r}_i}\right)+\sum_{i<j}\frac{e^2}{\varepsilon\,|\vec{r}_i-\vec{r}_j|}$$

$$H=\sum_i \frac{1}{r_s} v_F \vec{\sigma}\left(-\frac{\partial}{\partial \vec{r}_i}\right)+\frac{1}{r_s}\sum_{i<j}\frac{e^2}{\varepsilon\,|\vec{r}_i-\vec{r}_j|}$$

$$H=\left(\frac{1}{r_s} v_F\right)\left(\sum_i \vec{\sigma}\left(-\frac{\partial}{\partial \vec{r}_i}\right)+\frac{e^2}{2\varepsilon v_F}\sum_{i<j}\frac{2}{|\vec{r}_i-\vec{r}_j|}\right)$$



INDEPENDENT OF RS – DEPENDS ON SCREENING

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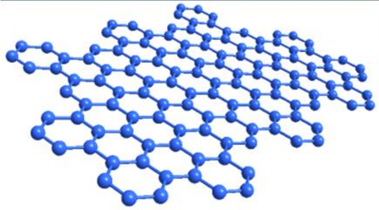
GRAPHENE QDOTS:

BANGAP, EXCITONS AND BIEXCITONS

SUBLATTICE ENGINEERING-MAGNETIC MOMENT AND E-E CORRELATIONS

SCREENING IN QUANTUM DOTS



Qdot Hamiltonian $$\hat{H}_0 = \sum_i \varepsilon_i c_i^+ c_i \quad + \sum_{i,j} t_{j,i} c_j^+ c_i$$

may include Pz (relevant) and Sigma (irrelevant) orbitals

Qdot energy spectrum and wavefunctions $$H_0 \varphi_i^0 = \varepsilon_i^0 \varphi_i^0$$

Introduce small *total* perturbation V $$H = H_0 + \delta \cdot V$$

Calculate perturbatively wavefunctions and energy levels of H

$$H\varphi_i = \varepsilon_i \varphi_i$$

$$\varphi_i = \varphi_i^0 + \delta\varphi_i^1 + \ldots \qquad \varepsilon_i = \varepsilon_i^0 + \delta\varepsilon_i^1 + \ldots$$

SCREENING IN QUANTUM DOTS

Calculate perturbatively wavefunctions and energy levels of H

$$\varphi_i(r) = \varphi_i^0(r) + \sum_{j \neq i} A_j^i \varphi_j^0(r)$$

$$\varphi_i(r) = \varphi_i^0(r) + \sum_{j \neq i} \frac{< j | V | i >}{\varepsilon_i - \varepsilon_j} \varphi_j^0(r)$$

Calculate charge density induced by perturbation V
(there are N electrons or N occupied states)

$$\rho(r) = \sum_{i=1}^{N} \varphi_i^*(r) \varphi_i(r)$$

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SCREENING IN QUANTUM DOTS

Calculate charge density induced by perturbation V

$$\rho(r) = \sum_{i=1}^{N} \varphi_i^*(r)\varphi_i(r)$$

$$\rho(r) = \sum_{i=1}^{N} (\varphi_i^0(r) + \sum_{k\neq i} \frac{<k|V|i>}{\varepsilon_i - \varepsilon_k} \varphi_k^0(r))^* (\varphi_i^0(r) + \sum_{j\neq i} \frac{<j|V|i>}{\varepsilon_i - \varepsilon_j} \varphi_j^0(r))$$

induced charge density is given by

$$\delta n(r') = \sum_{i,k;i\neq k} \left(\frac{f(\varepsilon_i) - f(\varepsilon_k)}{\varepsilon_i - \varepsilon_k} <i|V|k> \varphi_k^0(r')^* \varphi_i^0(r') \right)$$

polarizability

$$\delta n(r') = \sum_{i,k;i\neq k} \left(\Pi_{ik}^0 <i|V|k> \varphi_k^0(r')^* \varphi_i^0(r') \right)$$

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SCREENING IN QUANTUM DOTS

induced charge density is proportional to applied total but weak potential

$$\delta n(r') = \sum_{i,k;i\neq k} \left(\Pi^0_{ik} < i\,|V\,|\,k > \varphi^0_k(r')^* \varphi^0_i(r') \right)$$

Induced charge density produces induced potential dV

Total potential V is a sum of external potential and induced potential

$$V(r) = V^{ext}(r) + \delta V(r)$$

$$V(r) = V^{ext}(r) + \int dr' V^0(r,r') \delta n(r')$$

V0 may include image charges

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SCREENING IN QUANTUM DOTS

induced charge density is proportional to applied total weak potential

$$V(r) = V^{ext}(r) + \int dr' V^0(r,r')\delta n(r')$$

$$\delta n(r') = \sum_{i,k;i\neq k} \left(\Pi^0_{ik} < i|V|k > \varphi^0_k(r')^* \varphi^0_i(r') \right)$$

Take matrix elements of total potential, we end up with integral equation

$$< i|V|j > = < i|V^{ext}|j > + \sum_{k,l} < ik|V^0|lj > \Pi^0_{kl} < k|V|l >$$

$$V = V^{ext} + V^0 \Pi^0 V$$

$$V - V^0 \Pi^0 V = V^{ext}$$

$$V = \frac{V^{ext}}{1 - V^0 \Pi^0}$$

Screened RPA interaction

$$V = \frac{V^{ext}}{\varepsilon}$$

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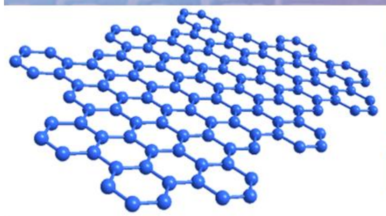
GRAPHENE QUANTUM CIRCUIT



GOAL FOR GRAPHENE QUANTUM DOTS

DEMONSTRATE CARBONONICS:

ELECTRONICS, PHOTONICS AND SPINTRONICS
IN A SINGLE MATERIAL
USING
LATERAL SIZE, SHAPE, EDGE, SUBLATTICE AND NUMBER OF LAYERS ENGINEERING OF GRAPHENE

INTEGRATE THESE FUNCTIONALITIES AT THE NANOSCALE
GRAPHENE INTEGRATED QUANTUM CIRCUIT

I.Ozfidan,D.Guclu,P.Potasz,M.Korkusinski,é PH

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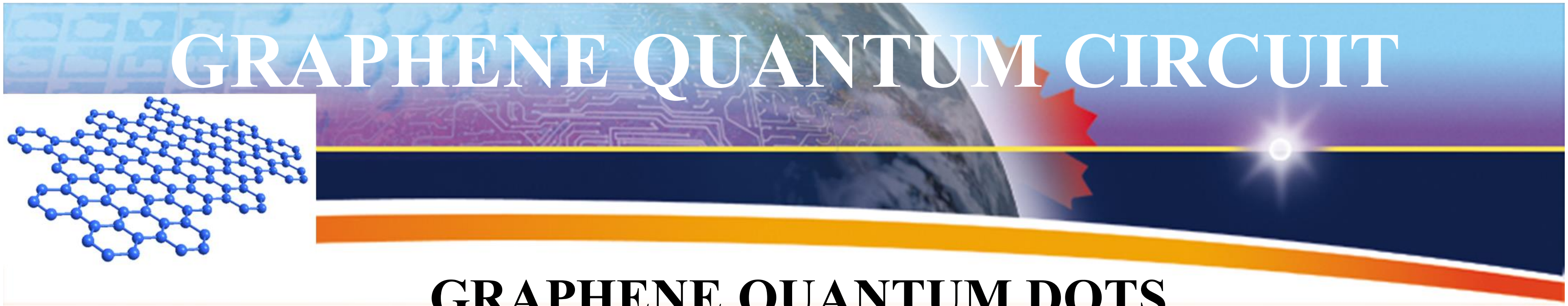

GRAPHENE QUANTUM DOTS
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2. A.D. Guclu, P. Potasz, O. Voznyy, M. Korkusinski, P. Hawrylak,ò Magnetism and correlations in fractionally filled degenerate shells of graphene quantum dotsò, Phys.Rev.Letters, **103**, 246805 (2009).
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1. D.Guclu, P. Potasz and P.Hawrylak, Zero-energy states of graphene triangular quantum dots in a magnetic fieldò, Phys.Rev.**B**88 155429 (2013)
2. I.Ozfidan, M. Korkusinski,A.D.Guclu,J.McGuire and P.Hawrylak, ñ Micoscopic theory of optical properties of colloidal graphene quantum dot Phys.Rev.B89,085310 (2014).
1. I.Ozfidan, M. Korkusinski and P.Hawrylak, ñTheory of Biexcitons and Biexciton-Exciton Cascade in Graphene Quantum Dotsò, Phys.Rev.B91, 115314(2015).
1. Cheng Sun, Florian Figge, I.Ozfidan, M. Korkusinski, Xin Yan, Liang-shi Li, Pawel Hawrylak and John A. McGuire, Biexciton binding in colloidal graphene quantum dotsò, NanoLetters 15,5742(2015).
1. Devrim Guclu, Pawel Potasz, Marek Korkusinski and Pawel Hawrylak,òGraphene Quantum Dotsò, Springer-Verlag (2014).
2. P Hawrylak, F Peeters, K Ensslin,Editors, ñCarbononicsï integrating electronics, photonics and spintronics with graphene quantum dotsò, Focus issue, Physica status solidi (RRL)-Rapid Research Letters 10 (1), 11 (2016).

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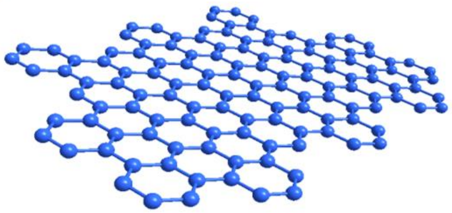


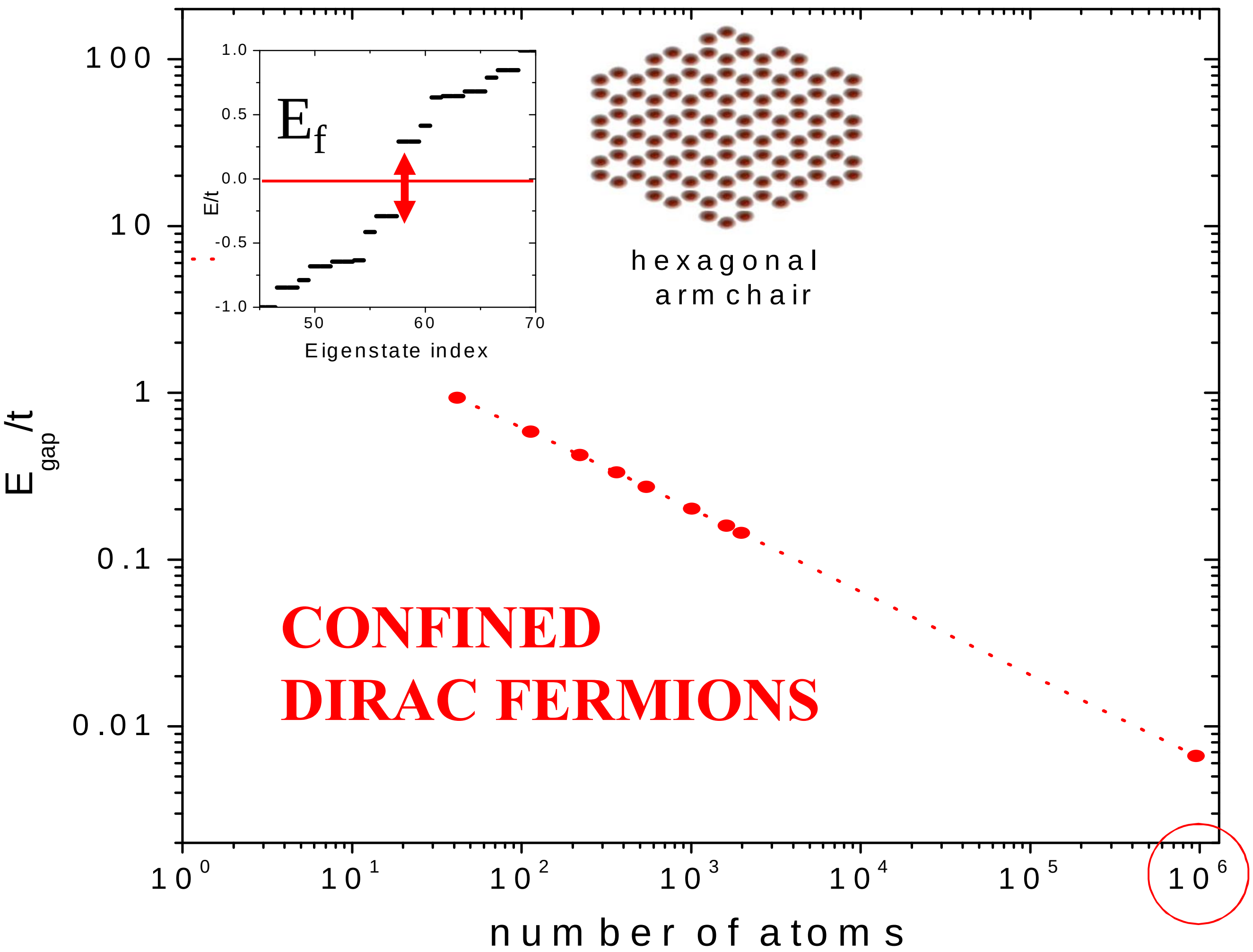
PHOTONICS
WITH GRAPHENE QUANTUM DOTS

MAKING A SEMICONDUCTOR OUT OF A SEMIMETAL

OPENING A GAP

BANDGAP ENGINEERING IN GRAPHENE QUANTUM DOTS

BAND GAP AS A FUNCTION OF SIZE



E=UV

E=THz

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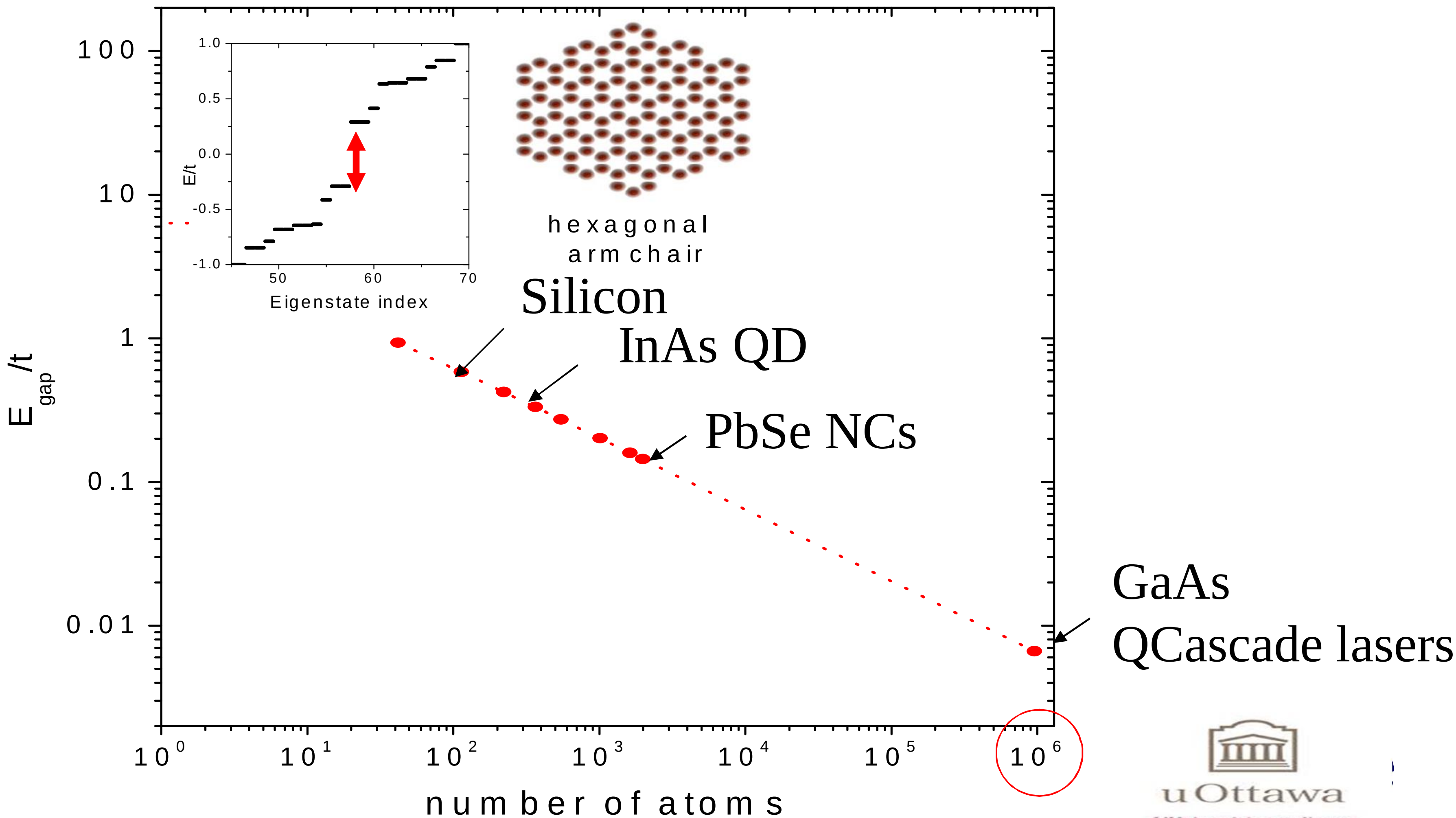
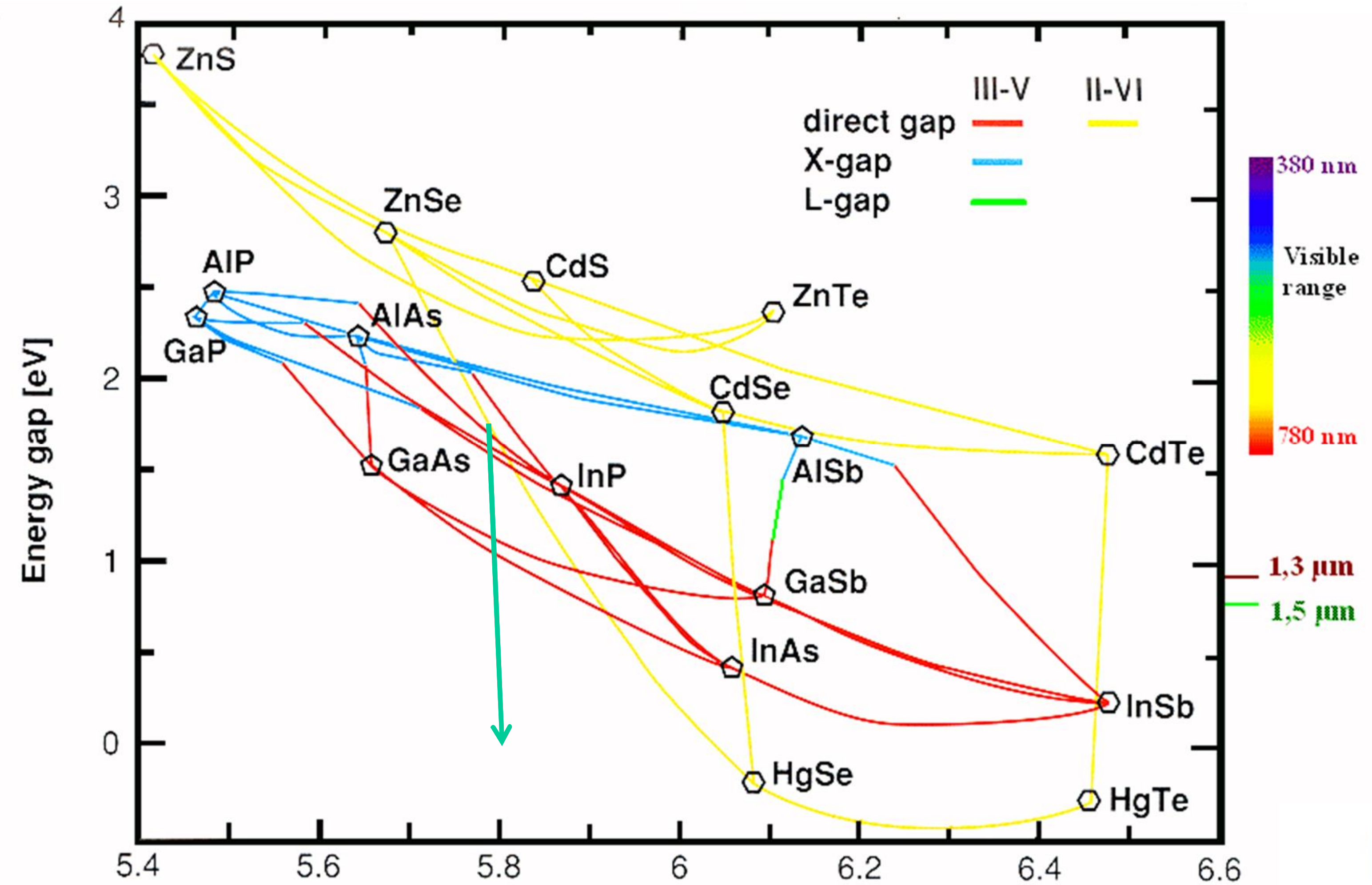
BANDGAP COMPARISON WITH SEMICONDUCTORS



BANDGAP ENGINEERING WITH COMPOUND SEMICONDUCTORS



Lattice constant

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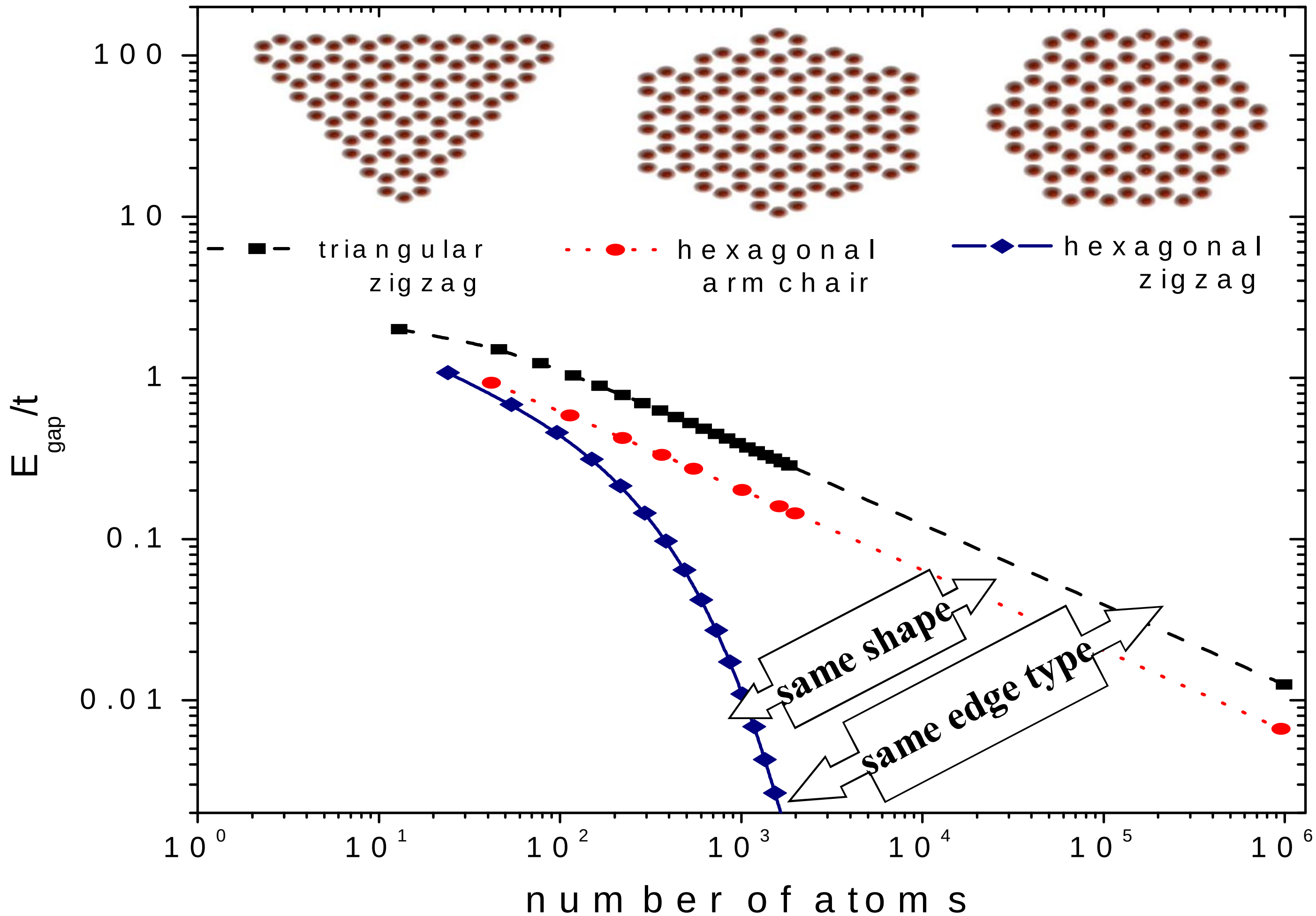
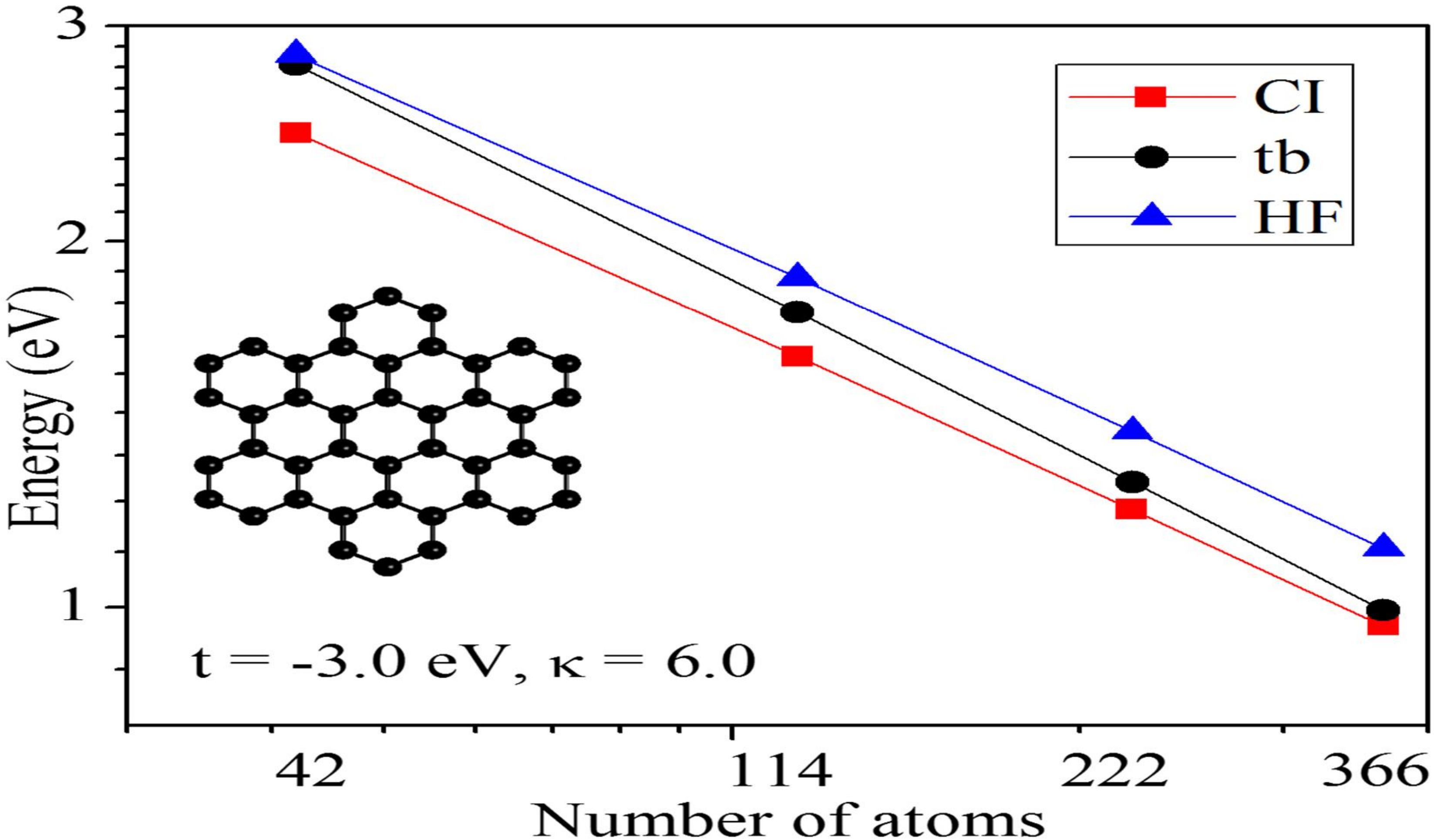
BANDGAP DEPENDS ON SIZE, EDGE AND SHAPE



Guclu.Potasz...PH.PRB2010

ELECTRONIC PROPERTIES OF GRAPHENE QUANTUM DOTS

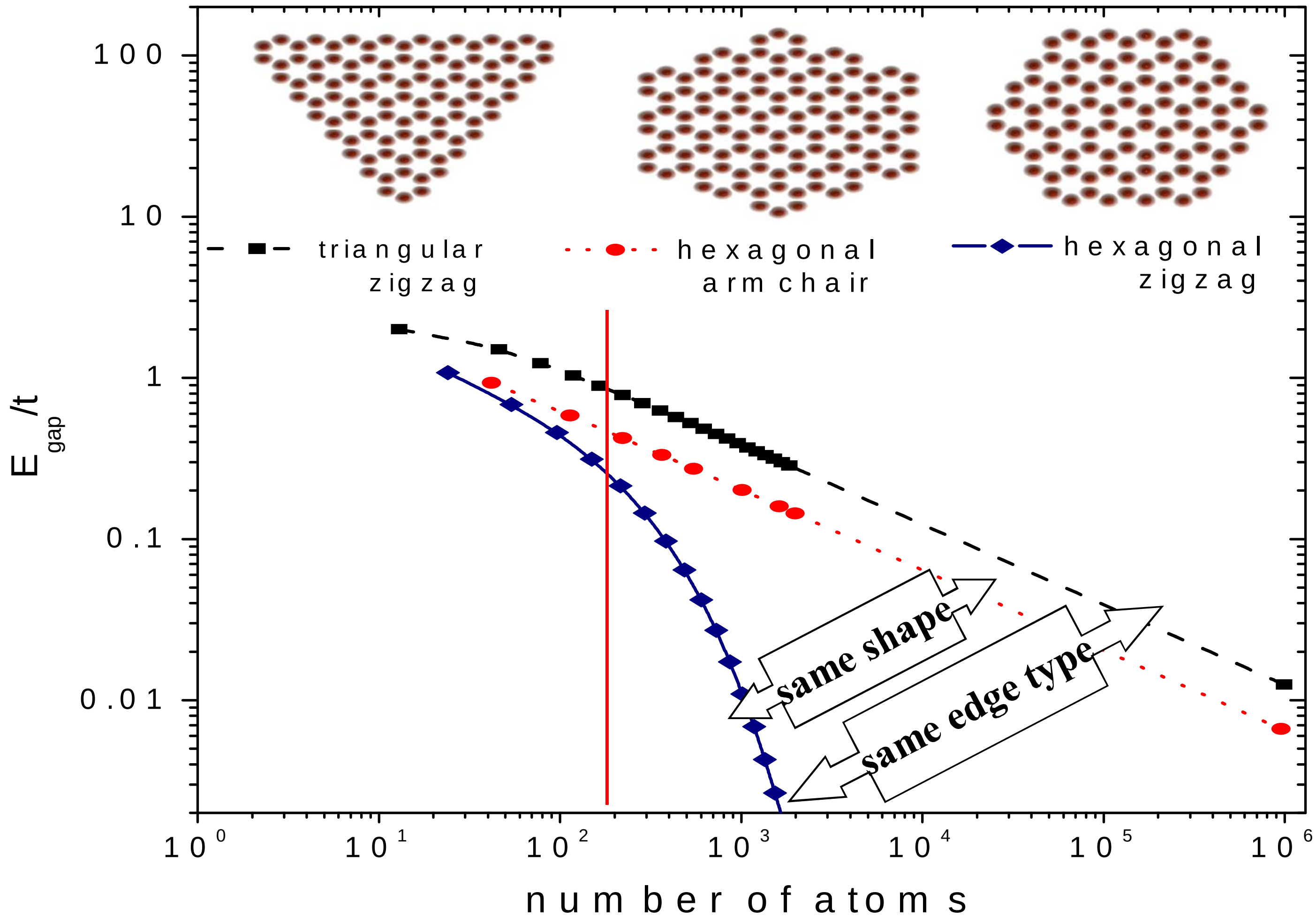
BANDGAP DEPENDS ON e-e INTERACTIONS



Ozfidan.PH.PSS2016

ELECTRONIC PROPERTIES OF GRAPHENE QUANTUM DOTS

BANDGAP DEPENDS ON SIZE, EDGE AND SHAPE



COLLOIDAL GRAPHENE QUANTUM DOTS

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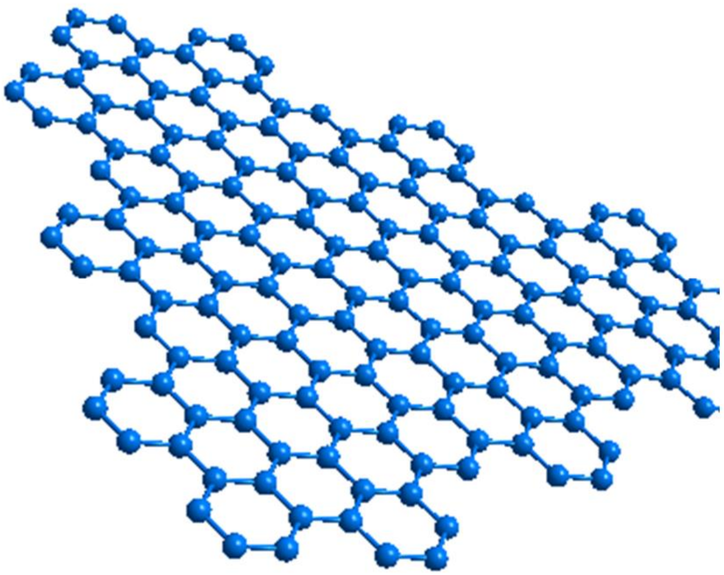
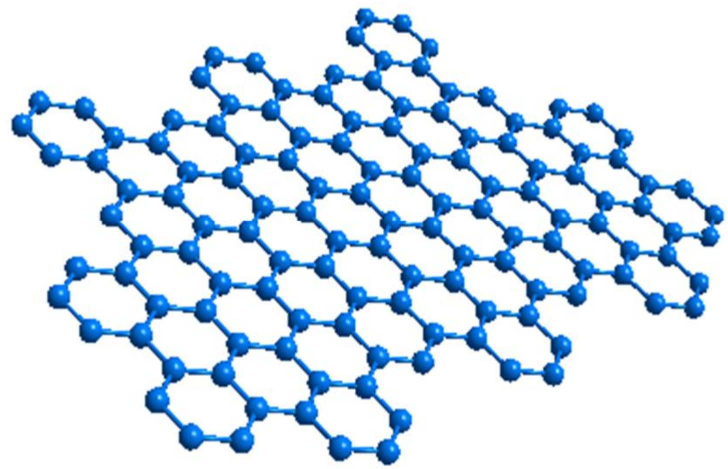
COLLOIDAL GRAPHENE QUANTUM DOTS

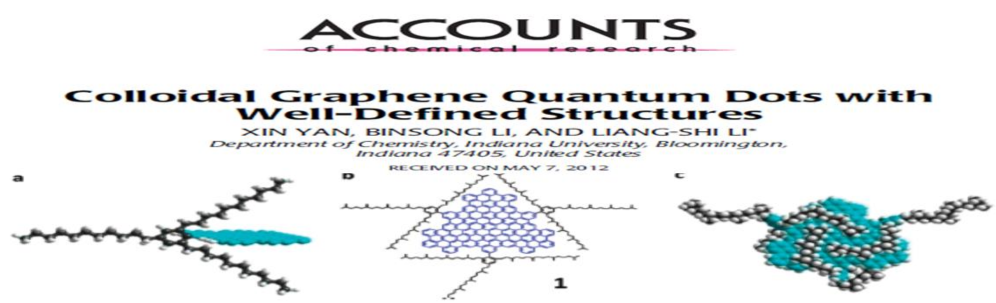
C168



C132
Broken symmetry



Number of C atoms – 168
Edges – mixed zigzag-armchair
Edges – H passivation

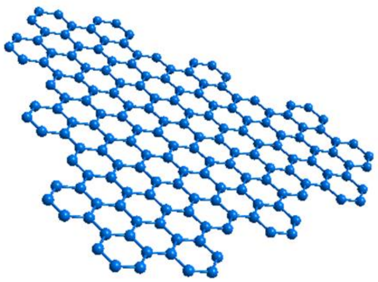

ACCOUNTS of chemical research

Colloidal Graphene Quantum Dots with Well-Defined Structures

XIN YAN, BINSONG LI, AND LIANG-SHI LI*
Department of Chemistry, Indiana University, Bloomington, Indiana 47405, United States

RECEIVED ON MAY 7, 2012

OPTICAL PROPERTIES OF GRAPHENE QUANTUM DOTS



Methodology: Tb+HF+CI

Pz orbitals only

$$H = \sum_{<i,j>} t_{ij} c^{+}_{i\sigma} c_{j\sigma}$$

t - tunneling

$$+ \frac{1}{2} \sum_{ijkl \; \sigma\sigma'} < ij \mid V \mid kl > c^{+}_{i\sigma} c^{+}_{j\sigma'} c_{k\sigma'} c_{l\sigma}$$

e-e interactions

$$< ij \mid V \mid kl >= \iint dr_1 dr_2 \, \phi_i^*(r_1) \, \phi_j^*(r_2) \frac{e^2}{\kappa \mid r_1 - r_2 \mid} \phi_k(r_2) \phi_l(r_1)$$

Slater-Koster orbitals

κ-screening by sigma electrons and surrounding fluid

D.GUCLU,P.POTASZ,M.KORKUSINSKI,O.VOZNYY,PH, PRL2009

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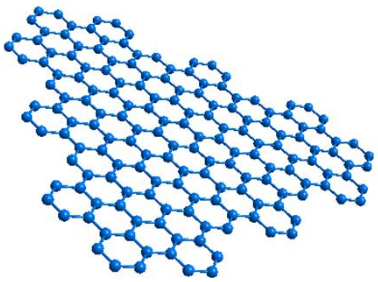
OPTICAL PROPERTIES OF GRAPHENE QUANTUM DOTS

Methodology: Tb+HF+CI



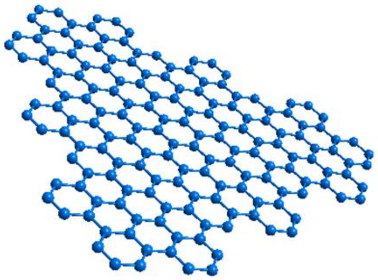
$$H = \sum_{<i,j>} t_{ij} c^{+}_{i\sigma} c_{j\sigma} + \frac{1}{2} \sum_{ijkl\,\sigma\sigma'} < ij \,|\, V \,|\, kl > c^{+}_{i\sigma} c^{+}_{j\sigma'} c_{k\sigma'} c_{l\sigma}$$

Hartree-Fock $\quad c^{+}_{i\sigma} \Rightarrow b^{+}_{i\sigma}$

$$H = \sum_{i} \varepsilon_i^{HF} b^{+}_{i\sigma} b_{i\sigma} - \sum_{i,j} V_{ij} b^{+}_{i\sigma} b_{j\sigma} + \frac{1}{2} \sum_{ijkl\,\sigma\sigma'} < ij \,|\, V^{HF} \,|\, kl > b^{+}_{i\sigma} b^{+}_{j\sigma'} b_{k\sigma'} b_{l\sigma}$$

Correlated ground and excited states

$$|\,\alpha> = (A^{\alpha} + \sum_{i,j} B^{\alpha}_{ij} b^{+}_{i\sigma} b_{j\sigma'} + \sum_{ijkl\sigma\sigma'} C^{\alpha}_{ijkl} b^{+}_{i\sigma} b^{+}_{j\sigma'} b_{k\sigma'} b_{l\sigma} + \sum_{ijklmn\sigma\sigma'\sigma''} D^{\alpha}_{ijkl} b^{+}_{i\sigma} b^{+}_{j\sigma'} b^{+}_{k\sigma''} b_{l\sigma''} b_{m\sigma'} b_{n\sigma} +)\,|\,GS_{HF}>$$



GROUND STATE OF C168
AS A FUNCTION OF STRENGTH OF
ELECTRON-ELECTRON INTERACTIONS

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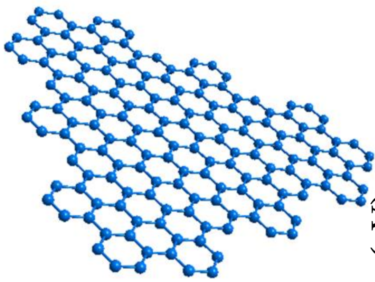
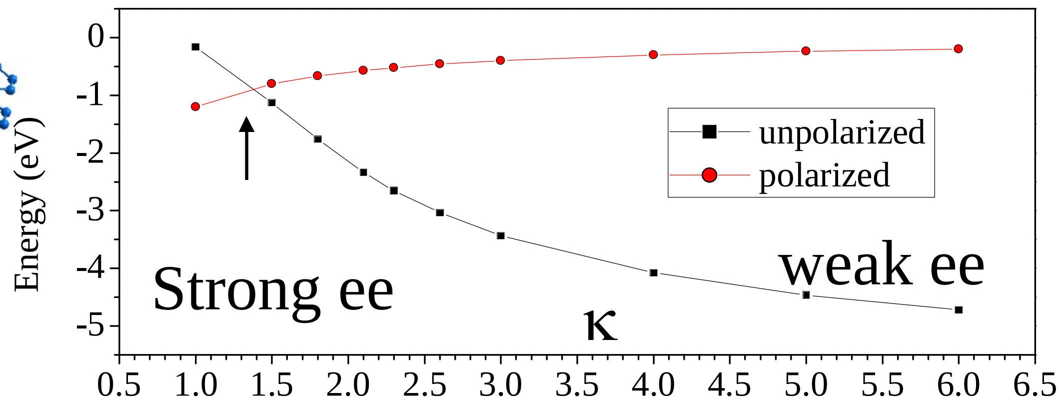
Tb+HF PHASE DIAGRAM



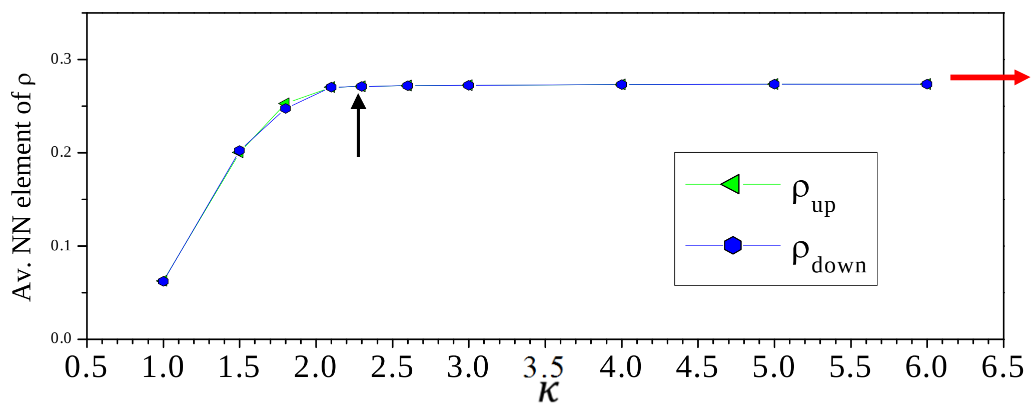
t=-4.0eV



Sz=N

Sz=0

Average NN density element in Sz=0 $< b^{+}_{a\uparrow} b_{b\uparrow} >$



Bulk HF graphene

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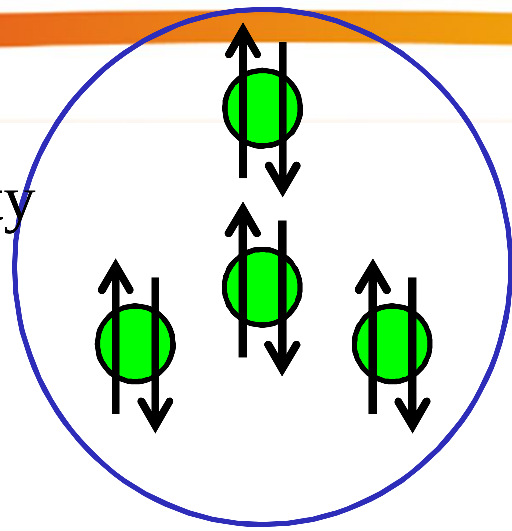
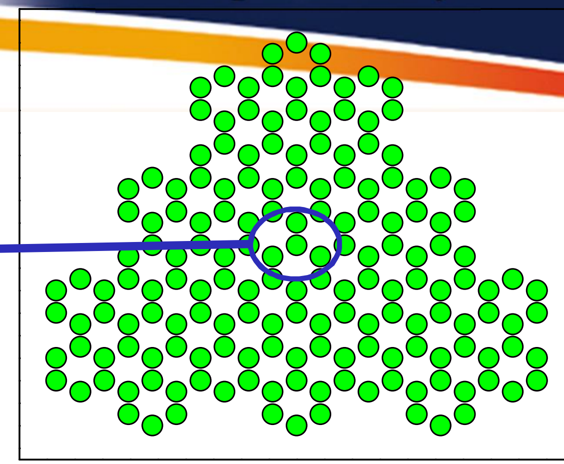
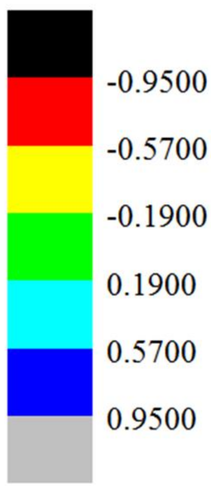
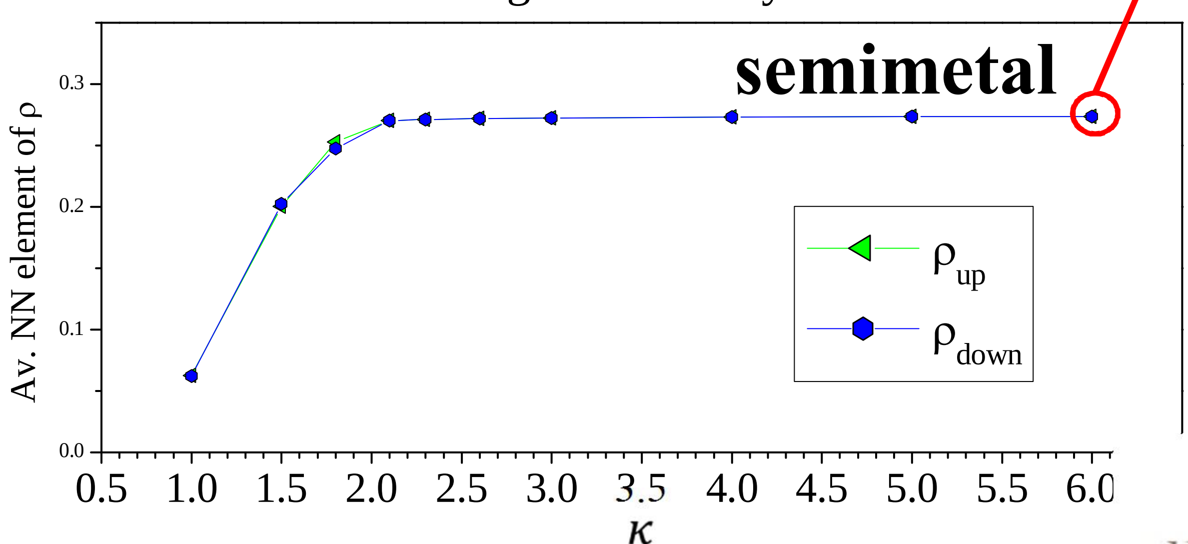
GROUND STATE OF GRAPHENE QUANTUM DOTS

Sz=0
Spin density









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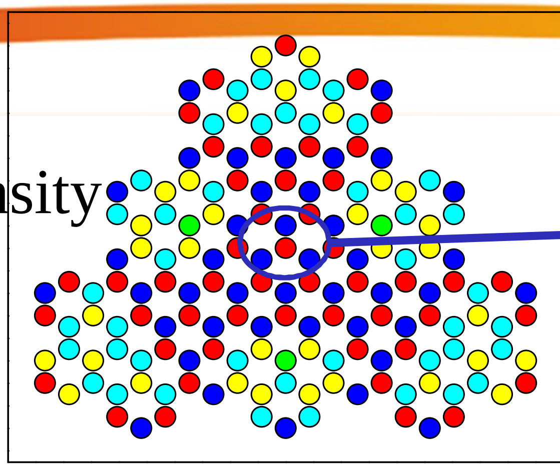
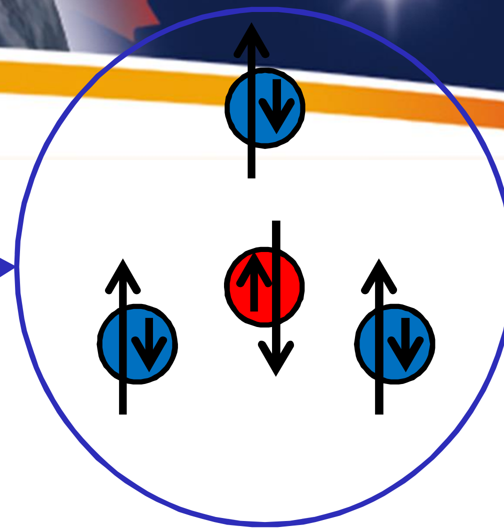
GROUND STATE OF GRAPHENE QUANTUM DOTS

Sz=0

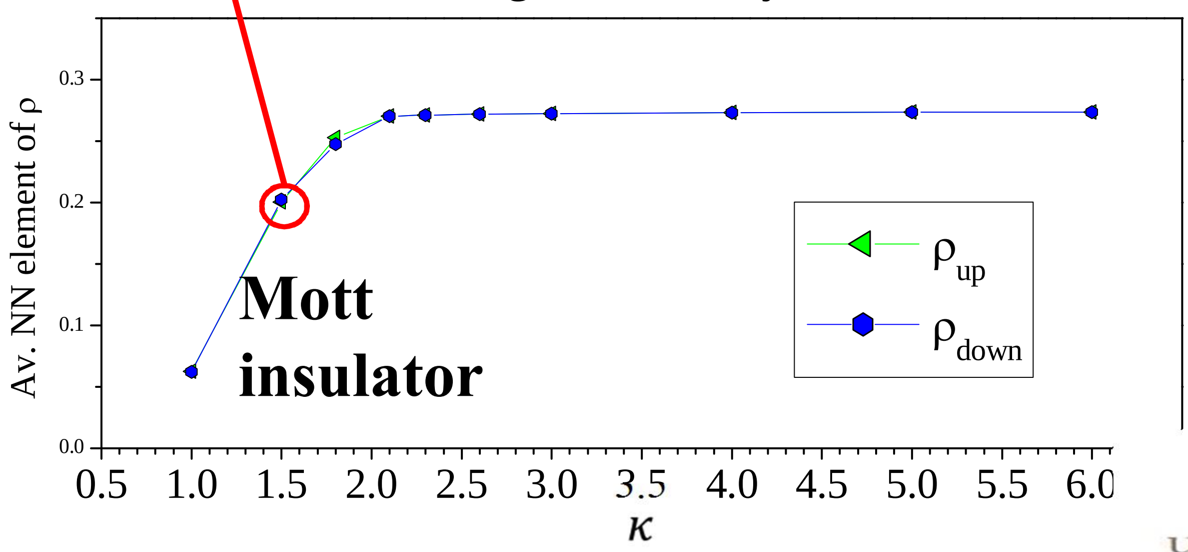
Spin density

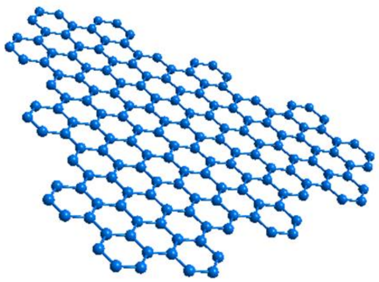




κ

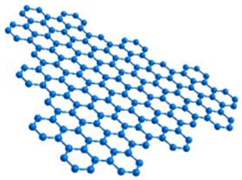
Average NN density element



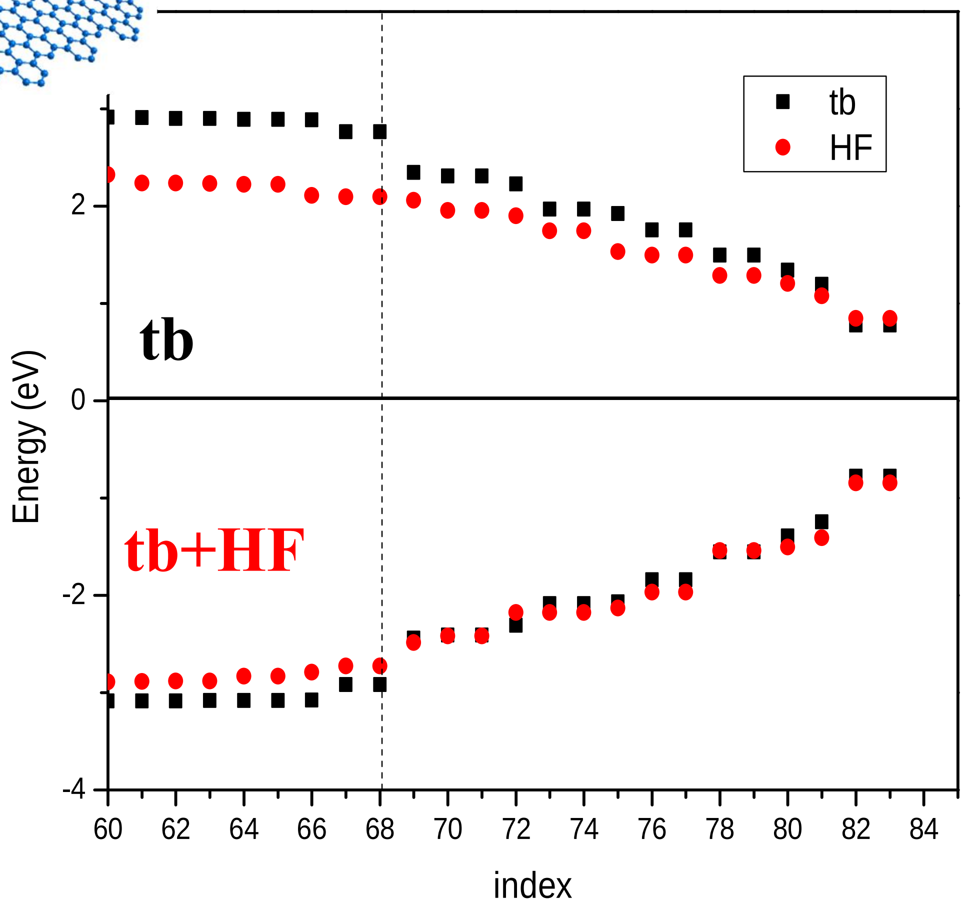


OPTICAL PROPERTIES OF C168 IN SEMIMETALLIC REGIME

OPTICAL PROPERTIES OF GRAPHENE QUANTUM DOTS



C168



CB

Ef **Tb and HF gaps almost identical**

VB

Ozfidan.Guclu.Korkusinski.PH

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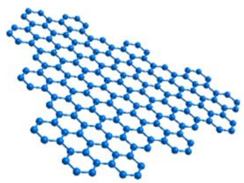
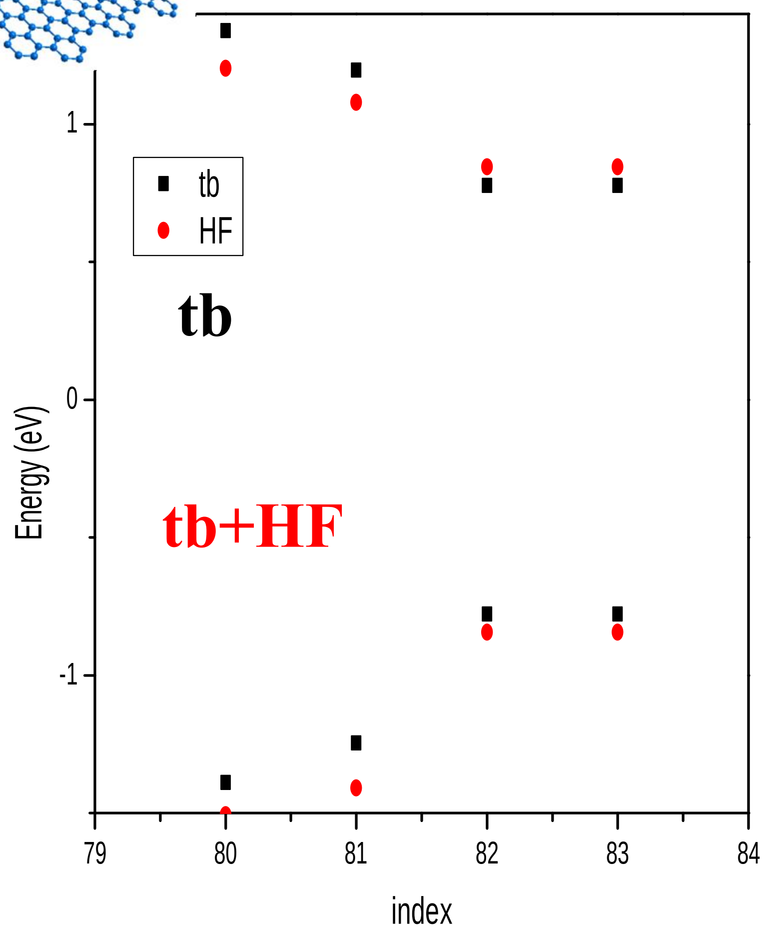
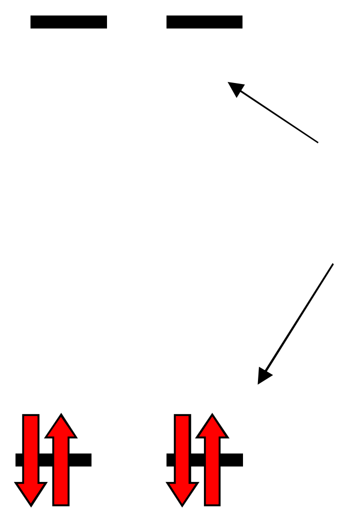
OPTICAL PROPERTIES OF GRAPHENE QUANTUM DOTS



C168



Bottom CB



DEGENERATE

Top VB

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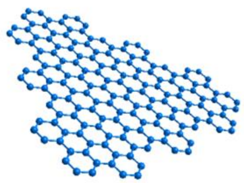
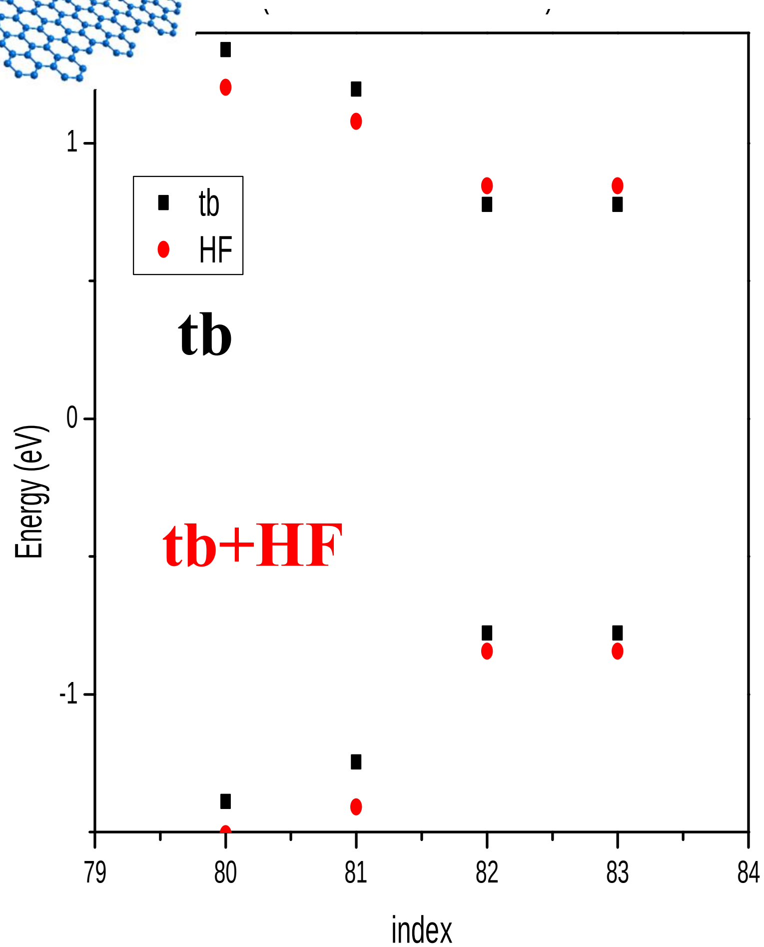
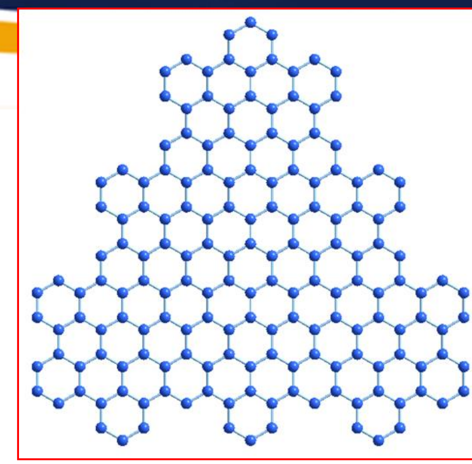
OPTICAL PROPERTIES OF GRAPHENE QUANTUM DOTS

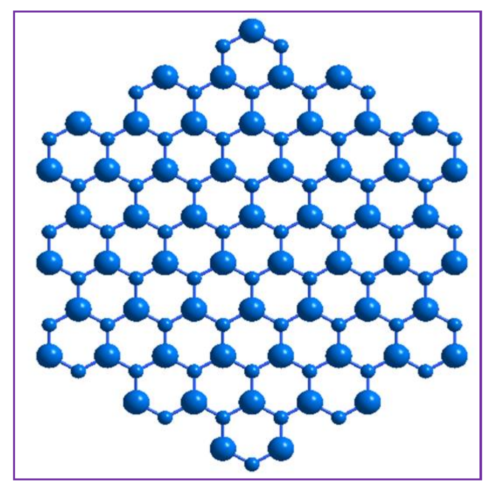


C168





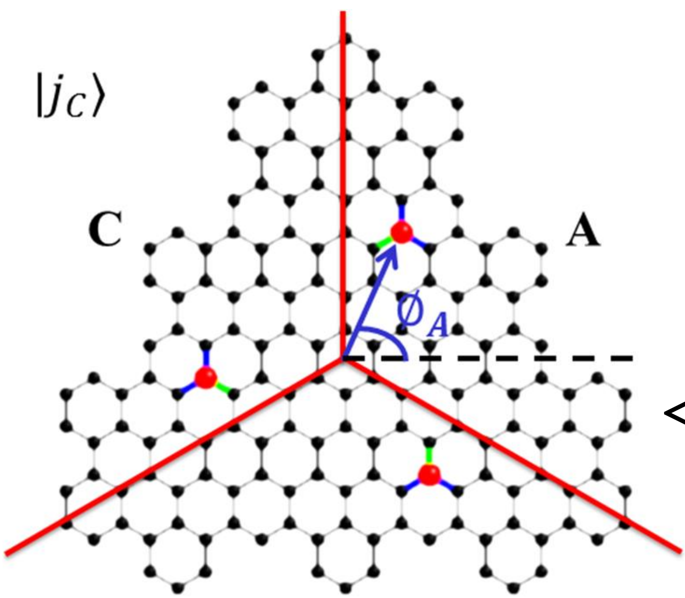
DEGENERACY IS ROBUST



Ozfidan.Guclu.Korkusinski.PH

DEGENERACY, DIPOLE ELEMENTS AND OPTICAL SELECTION RULES

DEGENERACY : VALLEY DEGENERACY / C3 SYMMETRY



$$\Psi_j^m = \frac{1}{\sqrt{3}} \sum_{\beta=0,1,2} e^{i\beta\cdot m\cdot 2\pi/3}|j_\beta\rangle$$

m=0,+1,-1
or
m=0,1,2

Degeneracy m=+/-1

$$< m,i\,|\,\vec{E}\cdot\vec{r}\,|\,m',j >= \delta_{m',m\pm1} D_{m,m',i,j}$$

Optical selection rules

$$\Delta m = \pm 1$$

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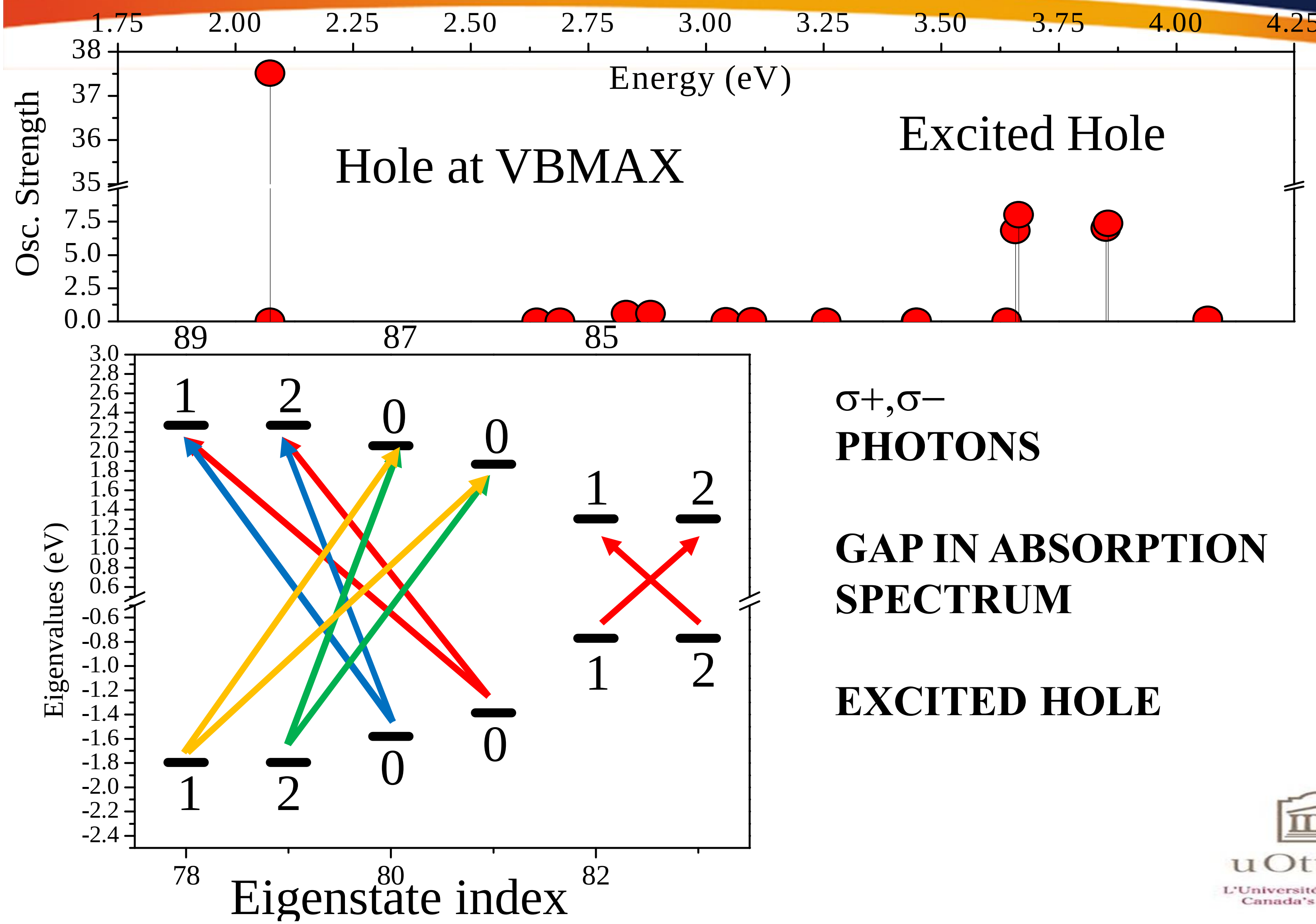
OPTICAL TRANSITIONS IN GRAPHENE QUANTUM DOTS

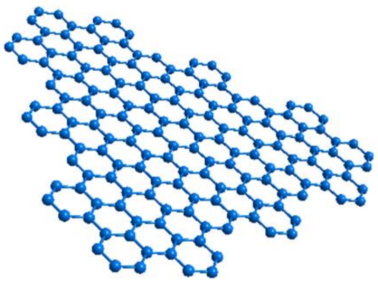


σ+,σ−

PHOTONS

GAP IN ABSORPTION SPECTRUM

EXCITED HOLE

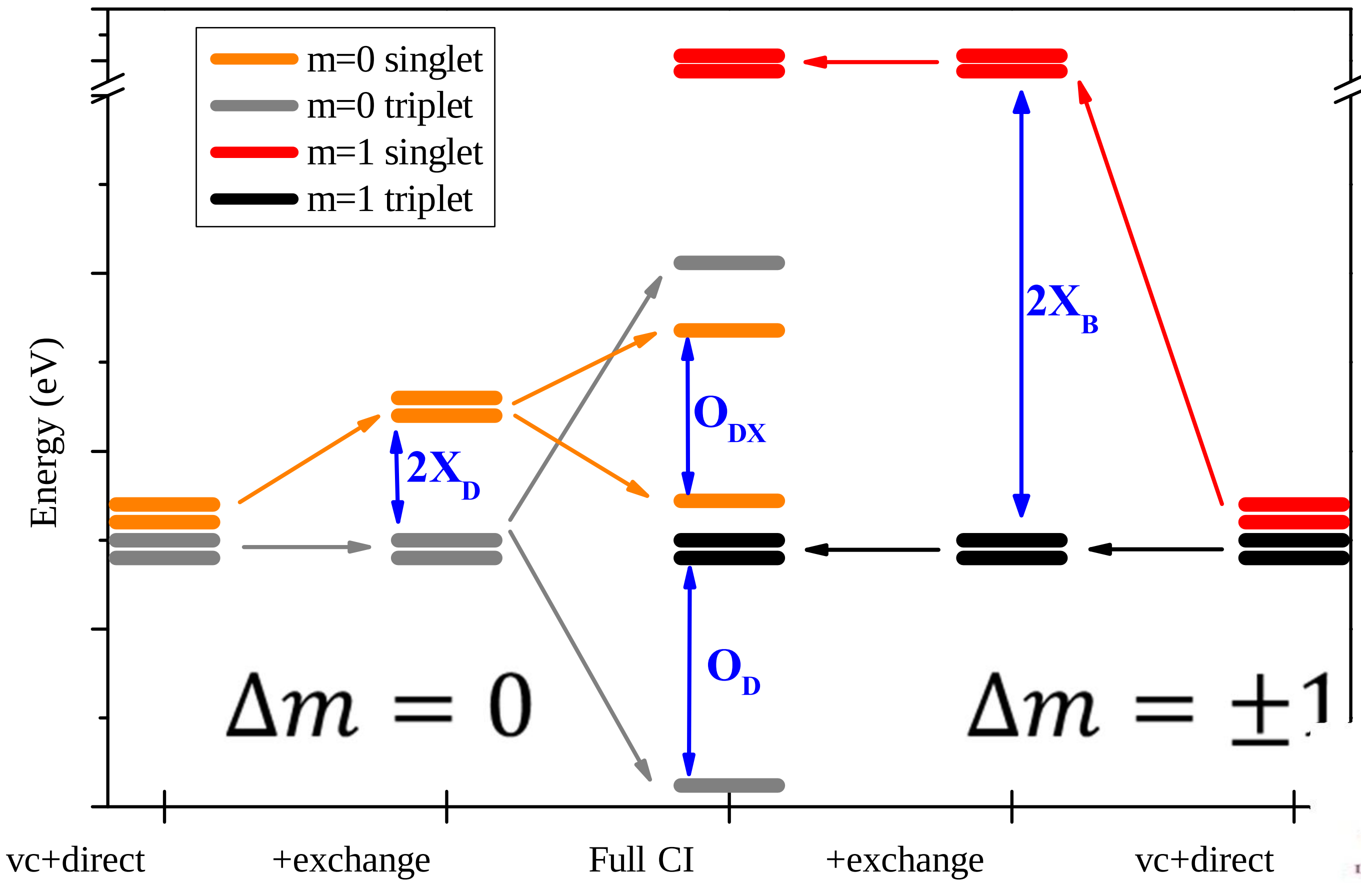


OPTICAL PROPERTIES OF C168 IN SEMIMETALLIC REGIME

SINGLET/TRIPLET EXCITONS AT THE BAND EDGE

EXCITONS AT THE DEGENERATE BAND EDGES

$$E_{S/T} = \varepsilon_p^c - \varepsilon_q^v + \Sigma(p) - \Sigma(q) - < pq \,|\, V_{HF}^0 \,|\, qp > + 2 < pq \,|\, V_{HF}^0 \,|\, pq > \; + \Delta_{corr}$$



TWO BRIGHT SINGLET EXCITONS

BAND OF DARK SINGLET AND TRIPLET EXCITONS

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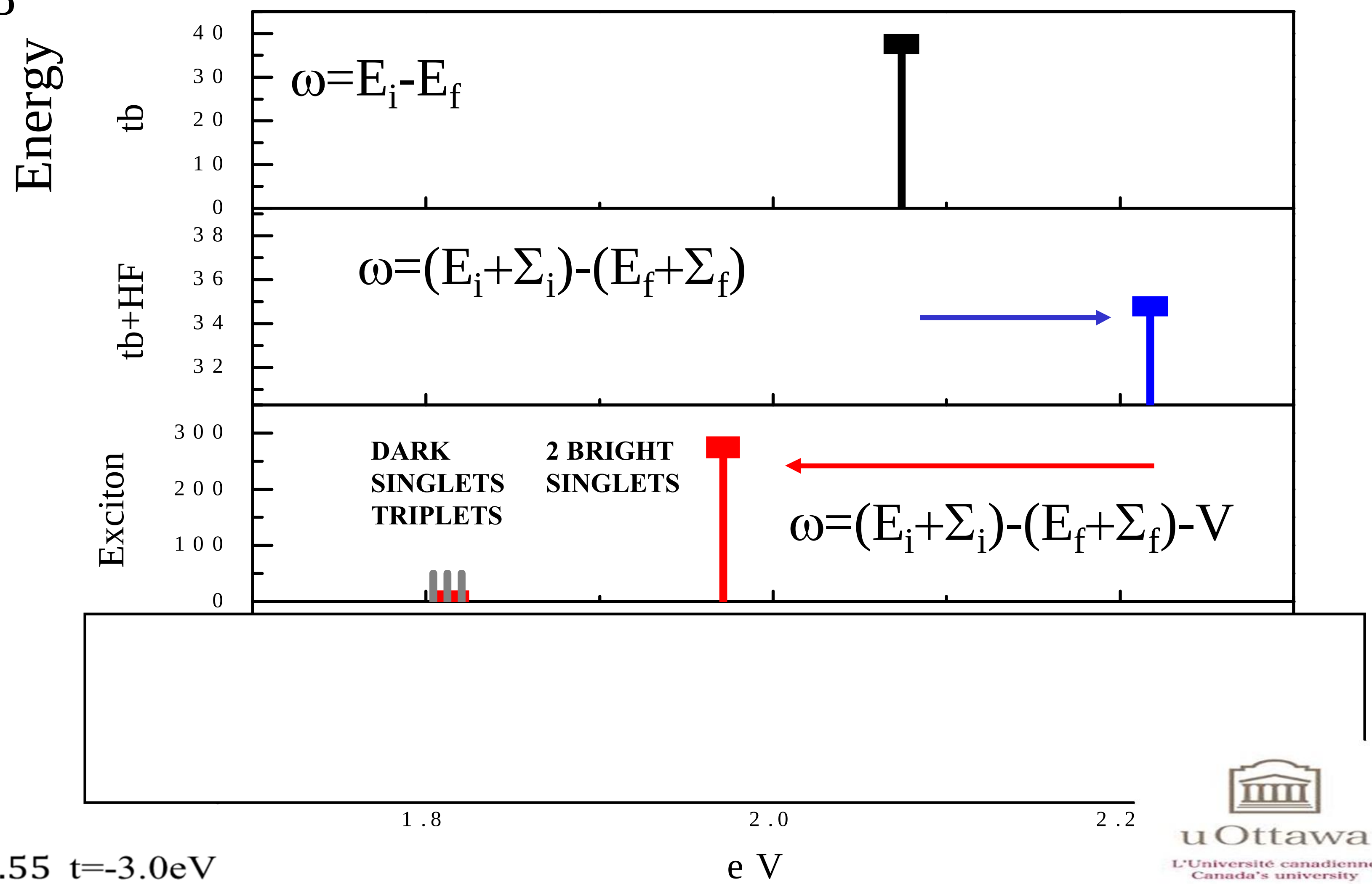
BAND EDGE ABSORPTION SPECTRUM

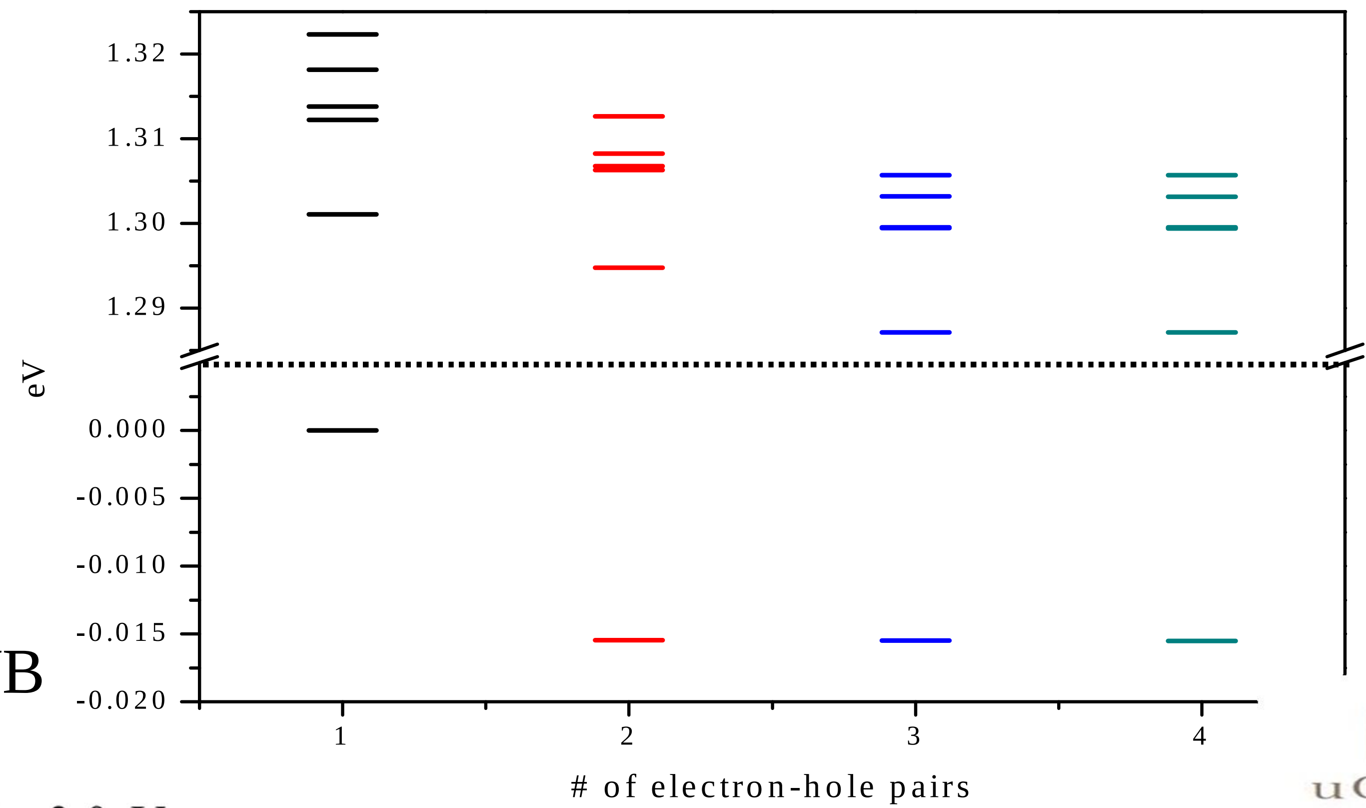
C168



$\kappa = 5.55$ t=-3.0eV

ROBUSTNESS OF BAND EDGE ABSORPTION SPECTRUM

$$|\alpha>=A^{\alpha}|GS_{HF}>+\sum_{i,j}B_{ij}^{\alpha}b_{i\sigma}^{+}b_{j\sigma'}+\sum_{ijkl\sigma\sigma'}C_{ijkl}^{\alpha}b_{i\sigma}^{+}b_{j\sigma'}^{+}b_{k\sigma'}b_{l\sigma}+\sum_{ijklmn\sigma\sigma'\sigma''}D_{ijkl}^{\alpha}b_{i\sigma}^{+}b_{j\sigma'}^{+}b_{k\sigma''}^{+}b_{l\sigma''}b_{m\sigma'}b_{n\sigma}+$$



4CB,4VB

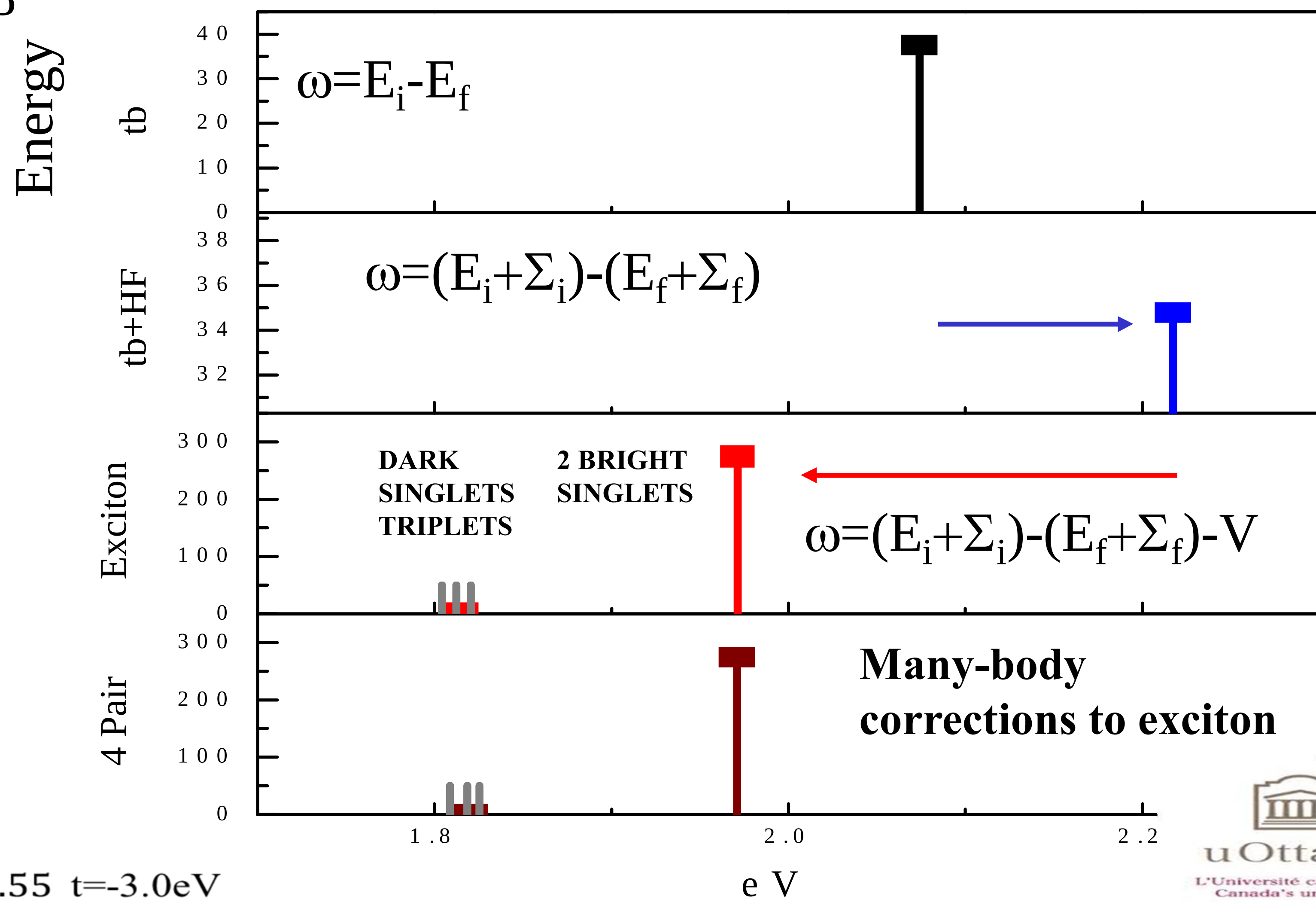
C168

$\kappa = 5.55$ t=-3.0eV

OPTICAL PROPERTIES OF GRAPHENE QUANTUM DOTS

C168

BAND EDGE ABSORPTION SPECTRUM



$\kappa = 5.55$ t=-3.0eV

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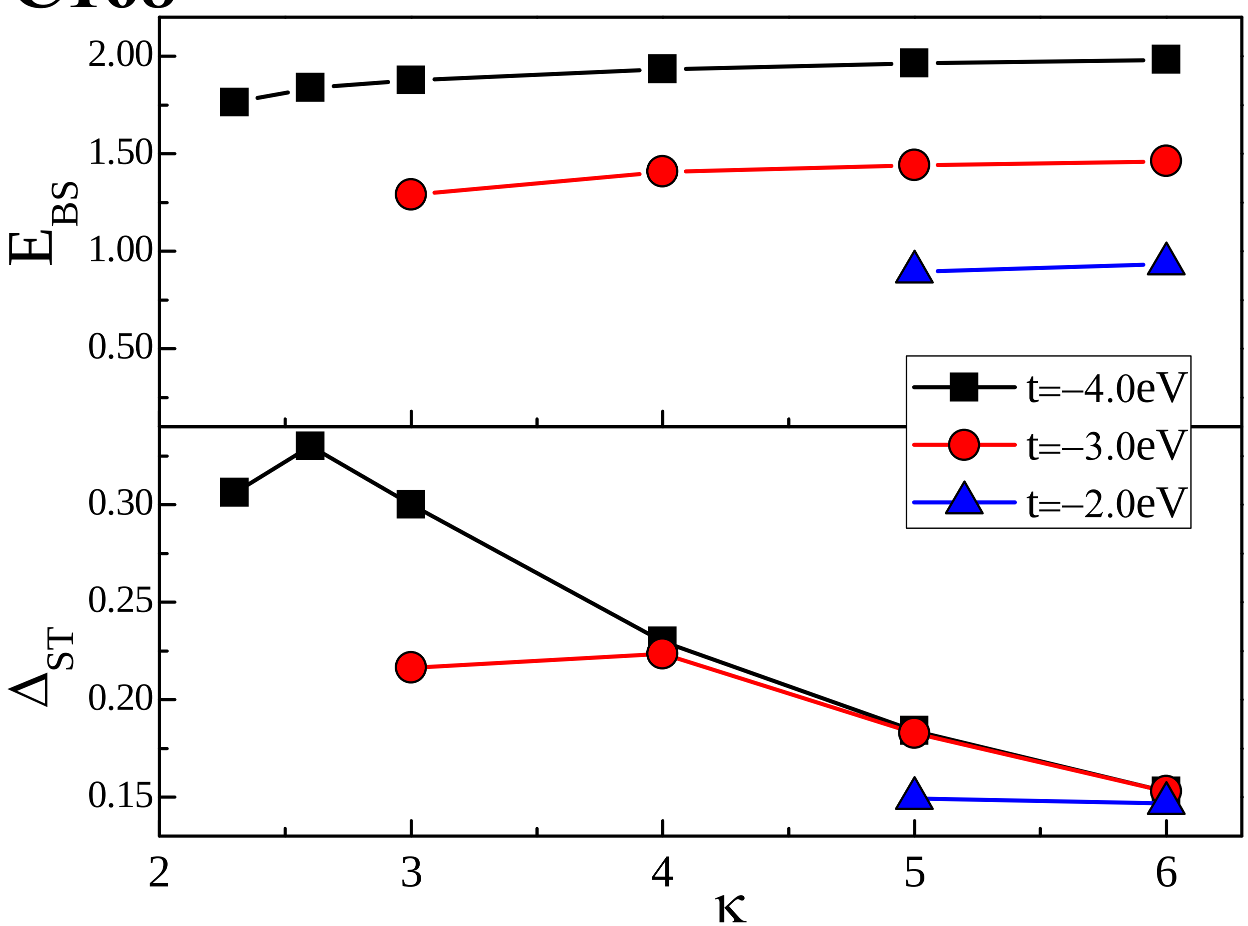
OPTICAL PROPERTIES OF GRAPHENE QUANTUM DOTS

EFFECT OF SCREENING ON BRIGHT/DARK EXCITON

C168



Energy of bright excitons depends on ñtò

S/T splitting depends on screening

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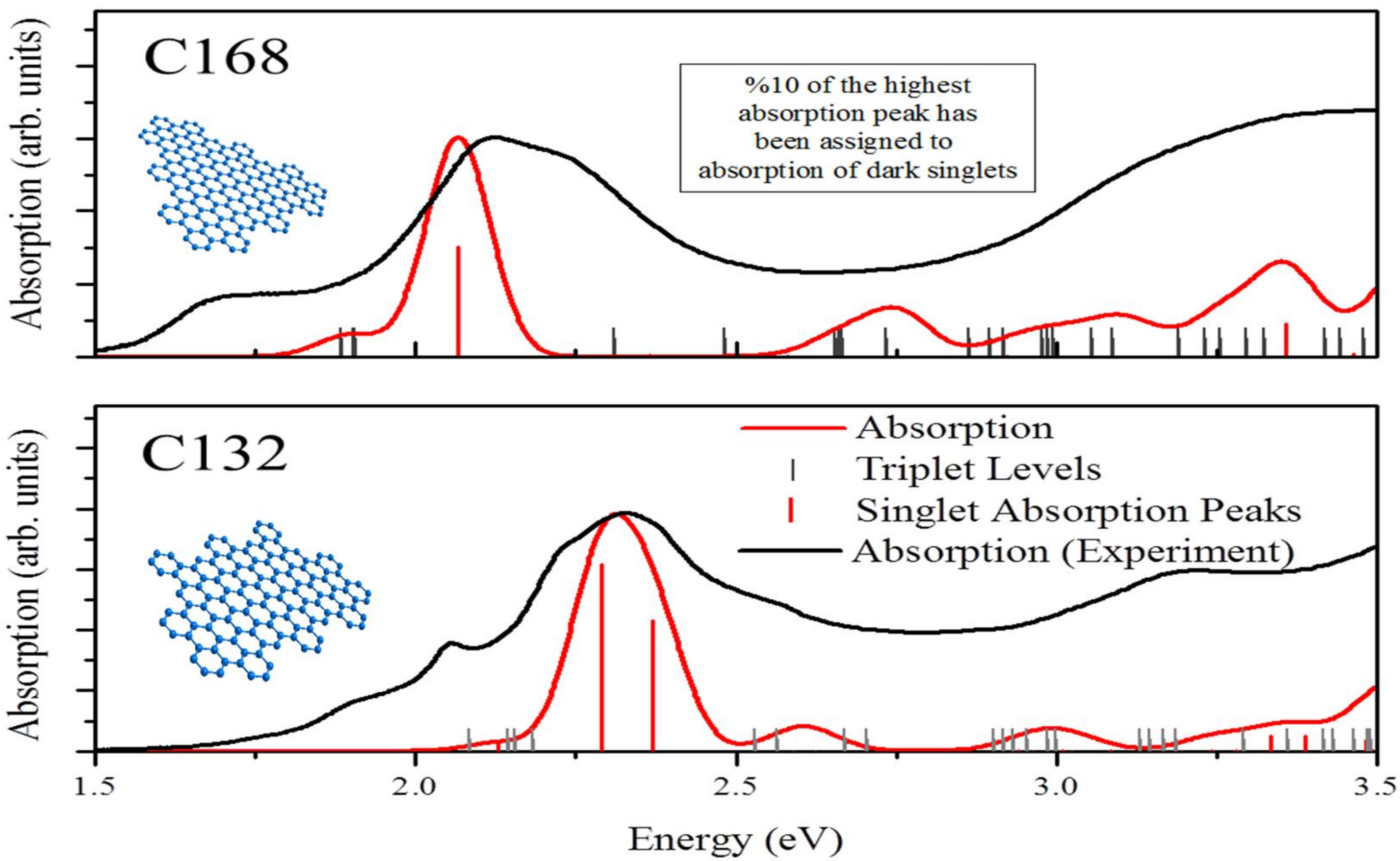
OPTICAL PROPERTIES OF GRAPHENE QUANTUM DOTS

ABSORPTION ï THEORY VS EXPERIMENT

Singlet-triplet splitting too small?

$\kappa=5, t=-4.2eV$



BLUE SHIFT

SPLITTING OF BRIGHT EXCITONS

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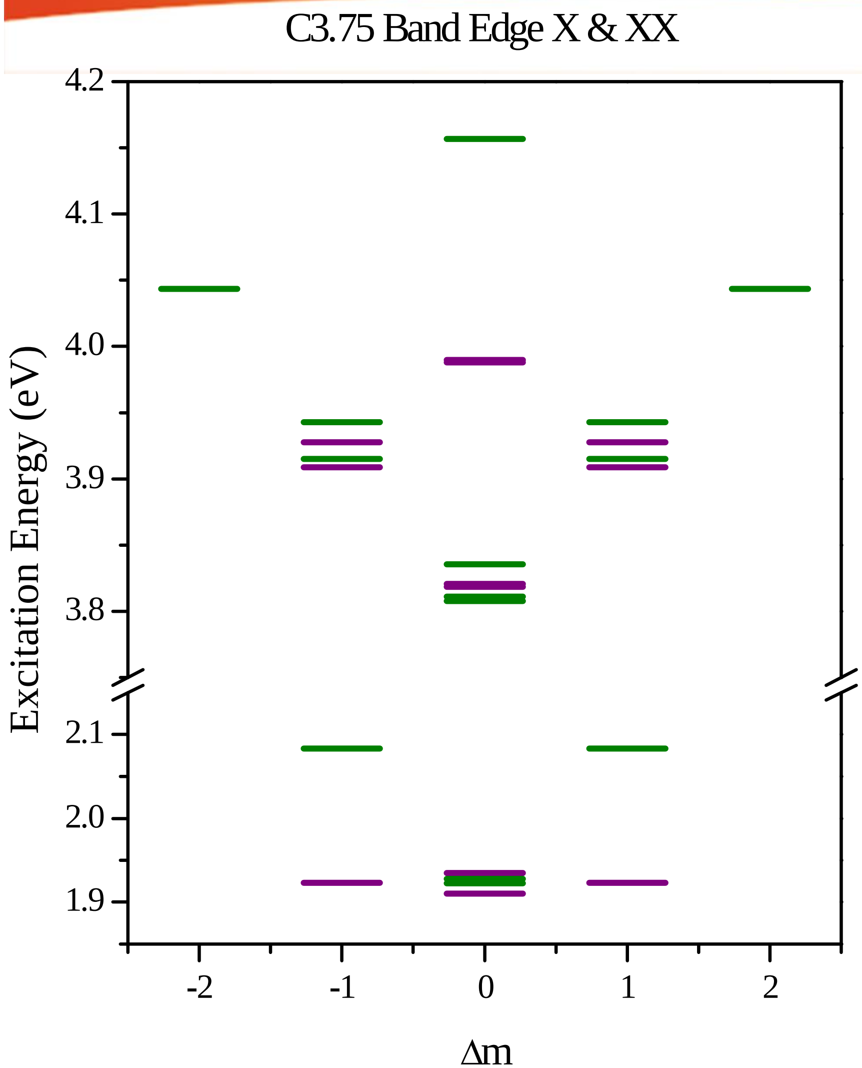
BIEXCITONS IN GRAPHENE QUANTUM DOTS



I.Ozfidan,M.Korkusinski,..PH

Condensation of Dirac excitons?

BAND OF BIEXCITONS

BAND OF EXCITONS

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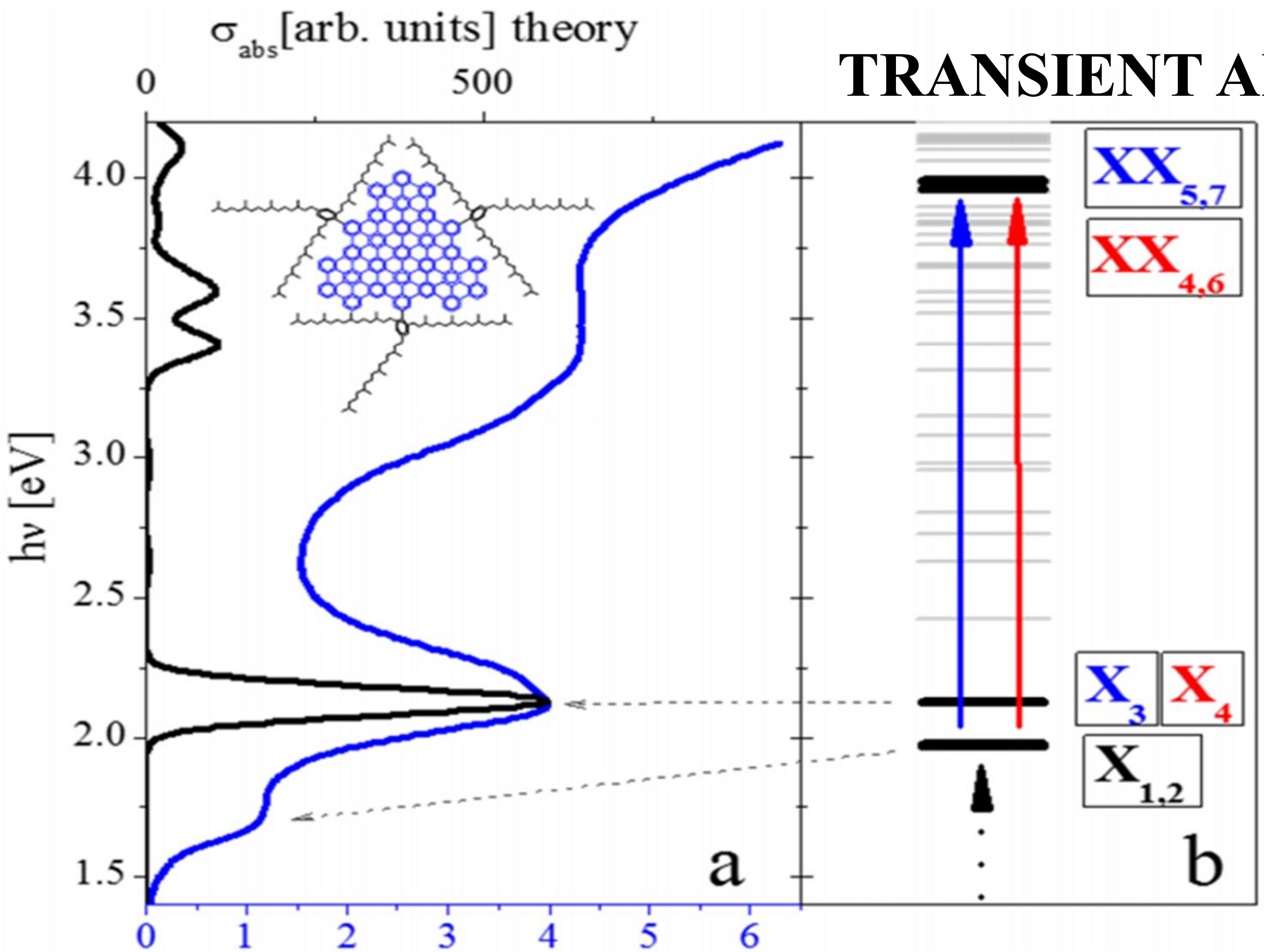
OPTICAL PROPERTIES OF GRAPHENE QUANTUM DOTS

THEORY **EXPERIMENT**

TRANSIENT ABSORPTION

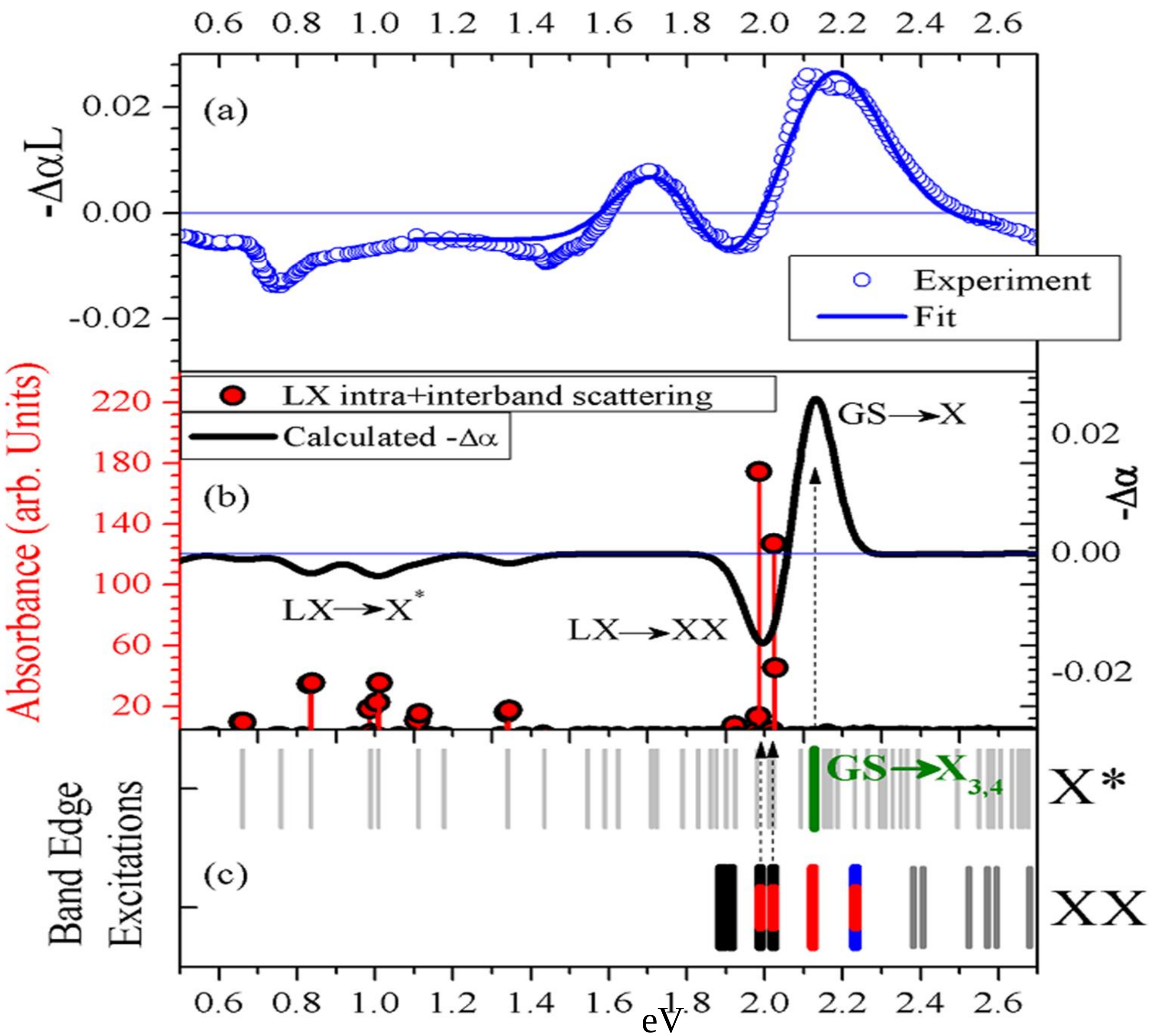


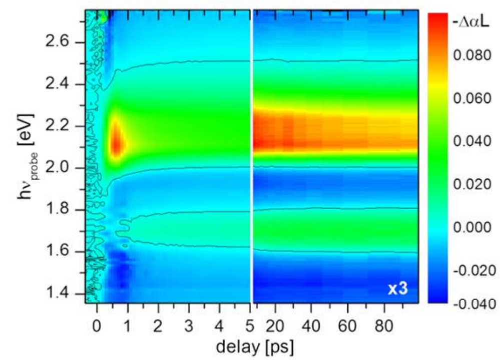
BIEXCITON BAND

EXCITON BAND

J.McGuire et al

TRANSIENT ABSORPTION-DETECTION OF EXCITED X* AND XX IN GRAPHENE QUANTUM DOTS





J.McGuire et al

DETECTING EXCITED X AND XX STATES

NanoLetters 2015

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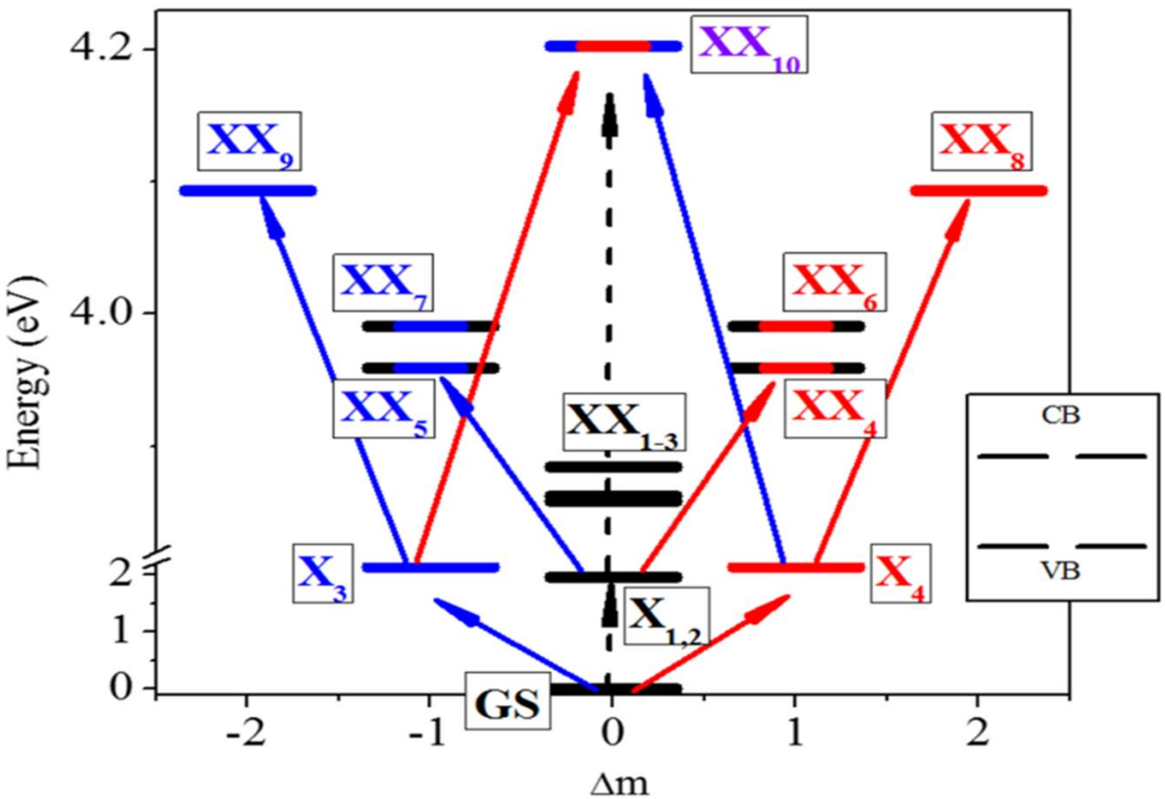
XX – X CASCADE FOR ENTANGLED PHOTON PAIR GENERATION



BIEXCITON-EXCITON CASCADE IN GRAPHENE QUANTUM DOTS

NO SIGN OF EXCITON CONDENSATION
BUT
STRONG X_X INTERACTION

OUTLINE

INTRODUCTION

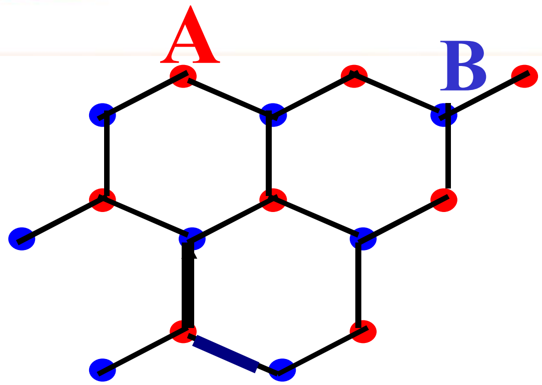
SCREENING IN QUANTUM DOTS (cRPA)

GRAPHENE QDOTS:

BANGAP, EXCITONS AND BIEXCITONS

SUBLATTICE ENGINEERING-MAGNETIC MOMENT AND E-E CORRELATIONS

CARBONONICS IN GRAPHENE



SPINTRONICS=SUBLATTICE ENGINEERING

SPINTRONICS RESTS ON LIEB'S THEOREM

GROUND STATE SPIN OF A HUBBARD MODEL ON BIPARTITE LATTICE

$$S=Na-Nb$$

SPINTRONICS = SUBLATTICE ENGINEERING

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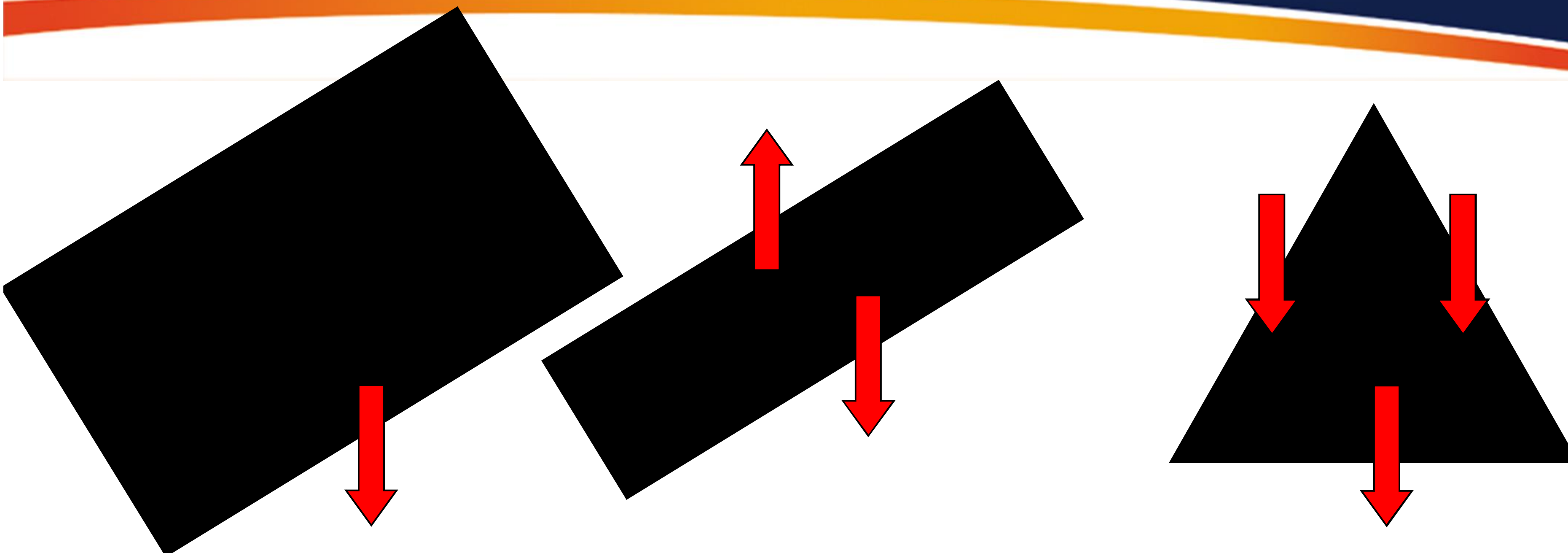
SPIN IN GRAPHENE, NANORIBBON AND TRIANGLE



Edge spin
Polarization
No gap

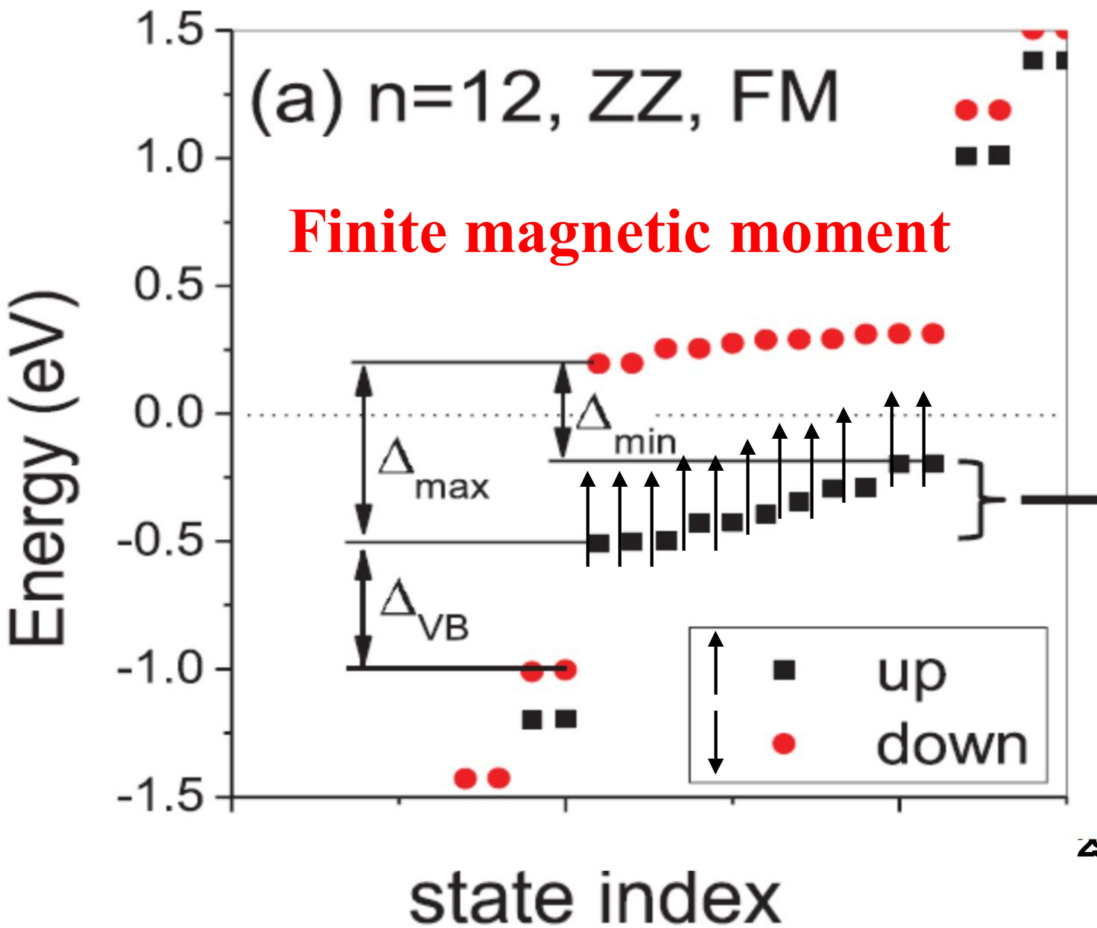
Gap but AF
Coupling
No net spin

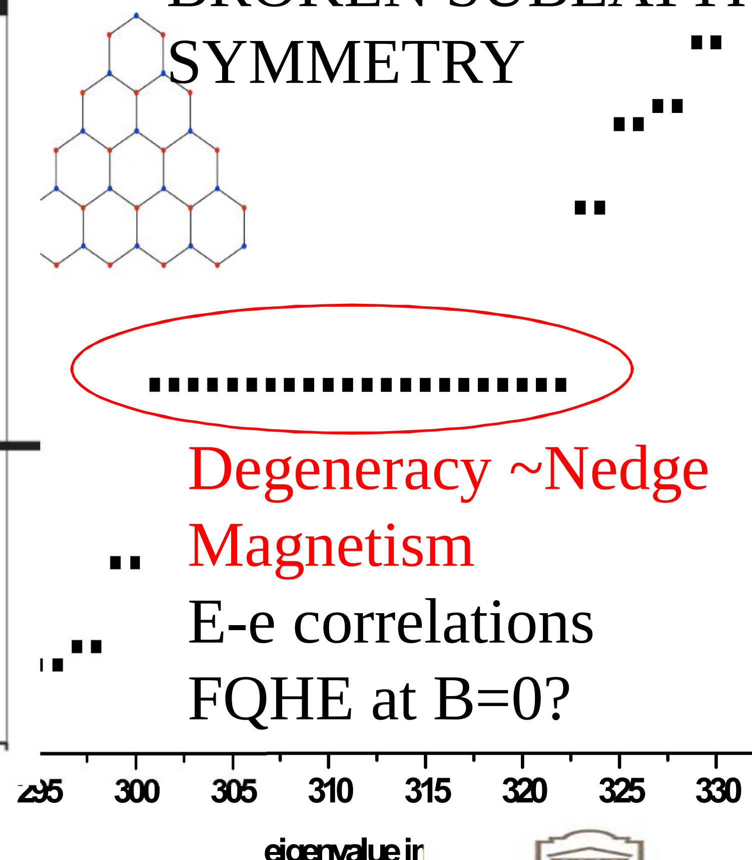
BROKEN
SUBLATTICE
SYMMETRY
Ferromagnetic coupling
Coupling Max spin

GRAPHENE QUANTUM DOTS

Ab-initio SIESTA

N=622, Nedge=23
BROKEN SUBLATTICE SYMMETRY



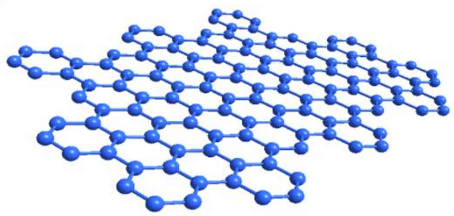


Degeneracy ~Nedge
Magnetism
E-e correlations
FQHE at B=0?

Voznyy,Guclu.. PH PRB2011

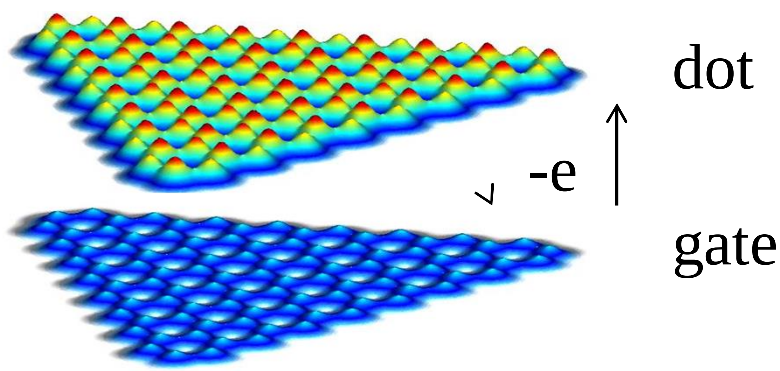
GRAPHENE QDOTS

TURNING OFF MAGNETISM WITH GATE(VOLTAGE)



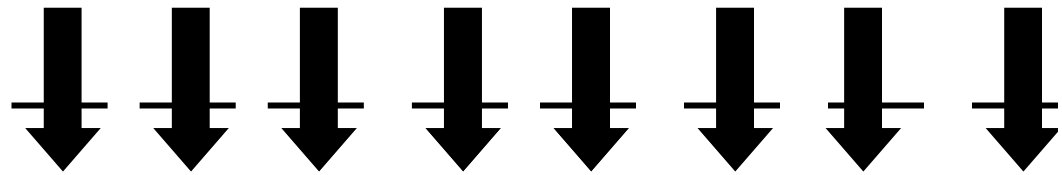
SPINTRONICS

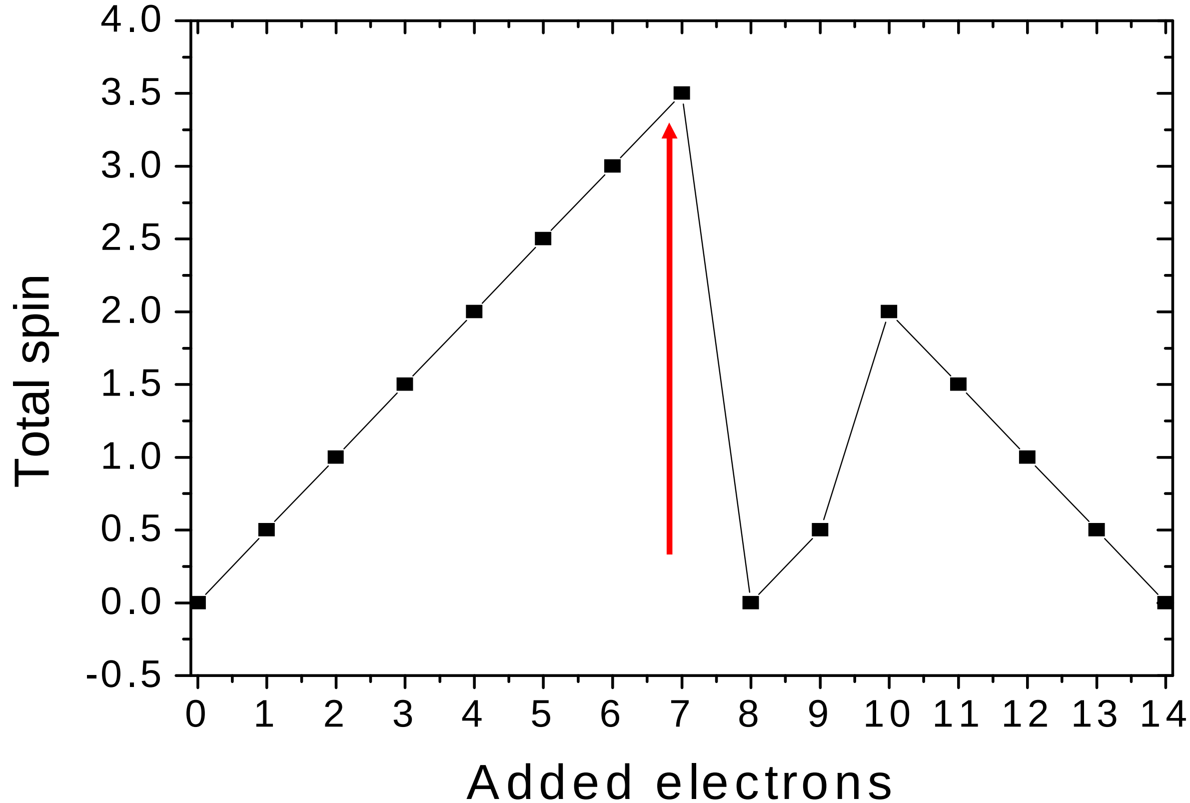
VOLTAGE CONTROL OF CHARGE DENSITY AND MAGNETIC MOMENT



FILLING UP ZERO-ENERGY HF SHELL

TOTAL SPIN OF ELECTRONS ON A DEGENERATE SHELL

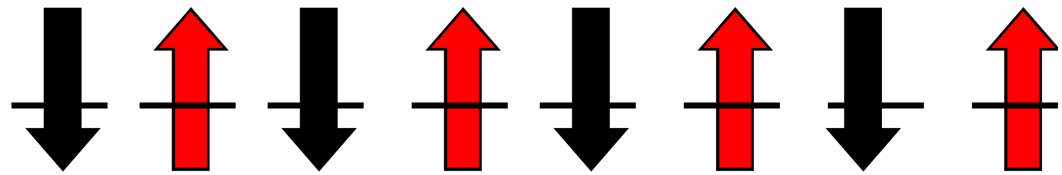


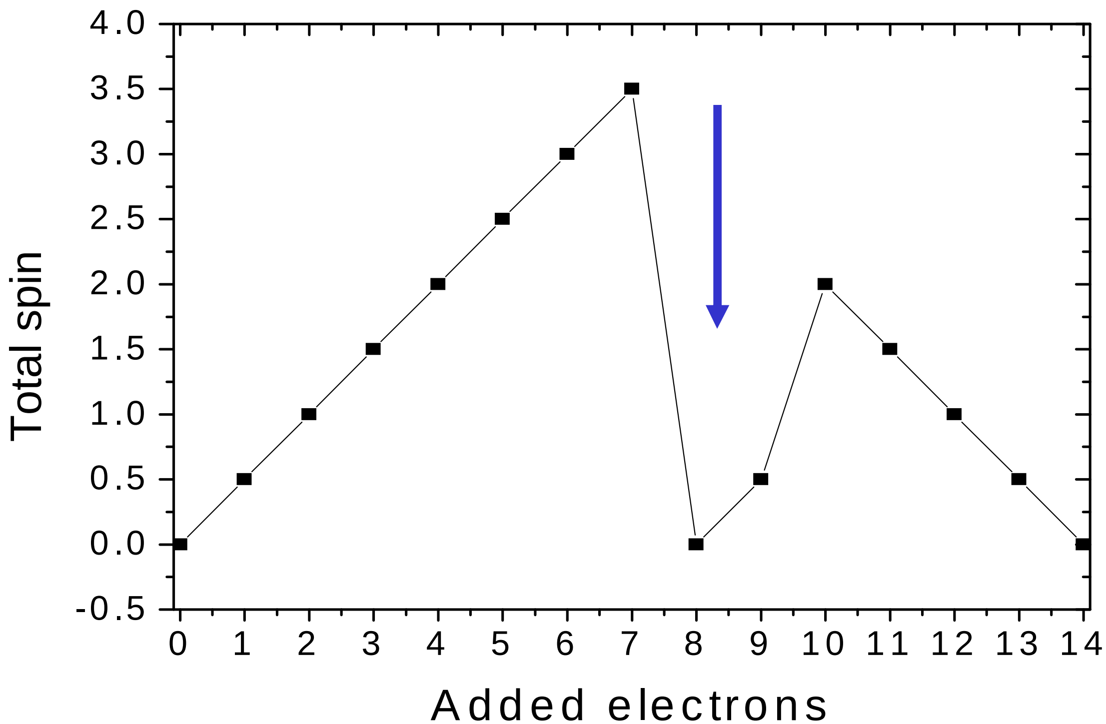


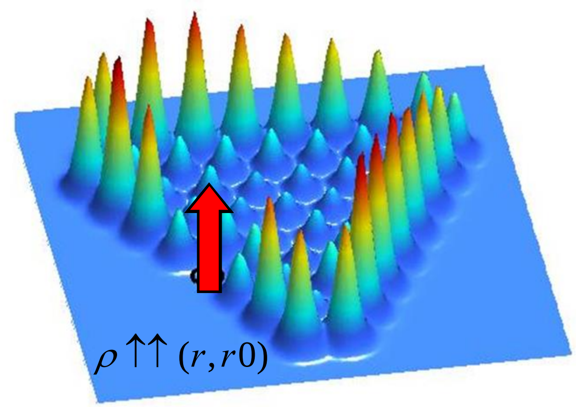
HALF FILLED SHELL
SPIN POLARISED
AS IN DFT/MEAN-FIELD
Ezawa;
Fernandez-Rossier&Palacios;
Kaxiras et al

FILLING UP ZERO-ENERGY HF SHELL

ADDING A SINGLE ELECTRON DEPOLARISES HALF FILLED SPIN POLARISED SHELL!







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GRAPHENE QUANTUM DOTS

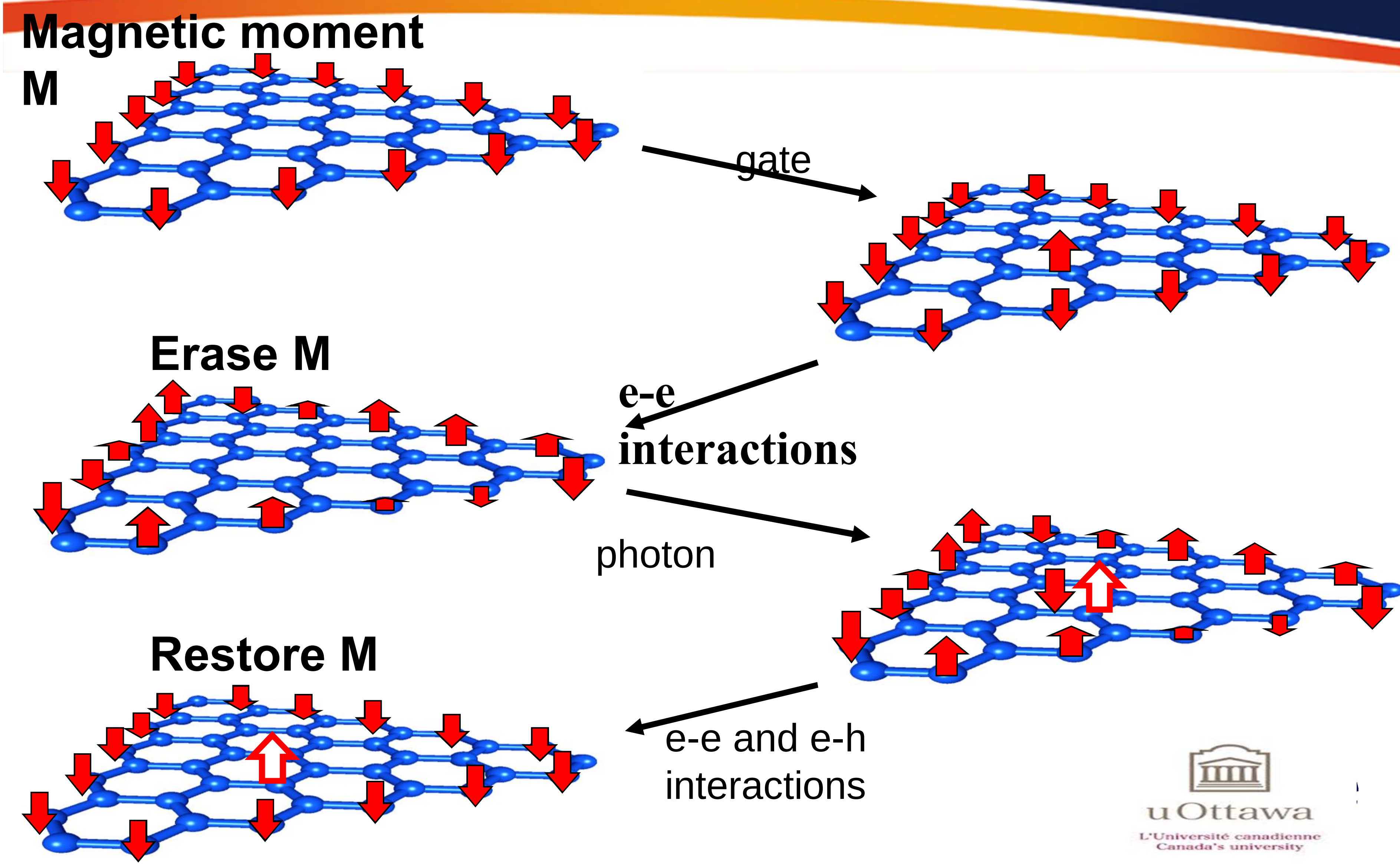
PHOTONICS AND SPINTRONICS

GRAPHENE QDOTS

TURNING OFF MAGNETISM
WITH GATE AND LIGHT

OPTICAL SPIN BLOCKADE

OPTICAL MANIPULATION OF SPIN AND OPTICAL SPIN BLOCKADE IN GRAPHENE QUANTUM DOTS



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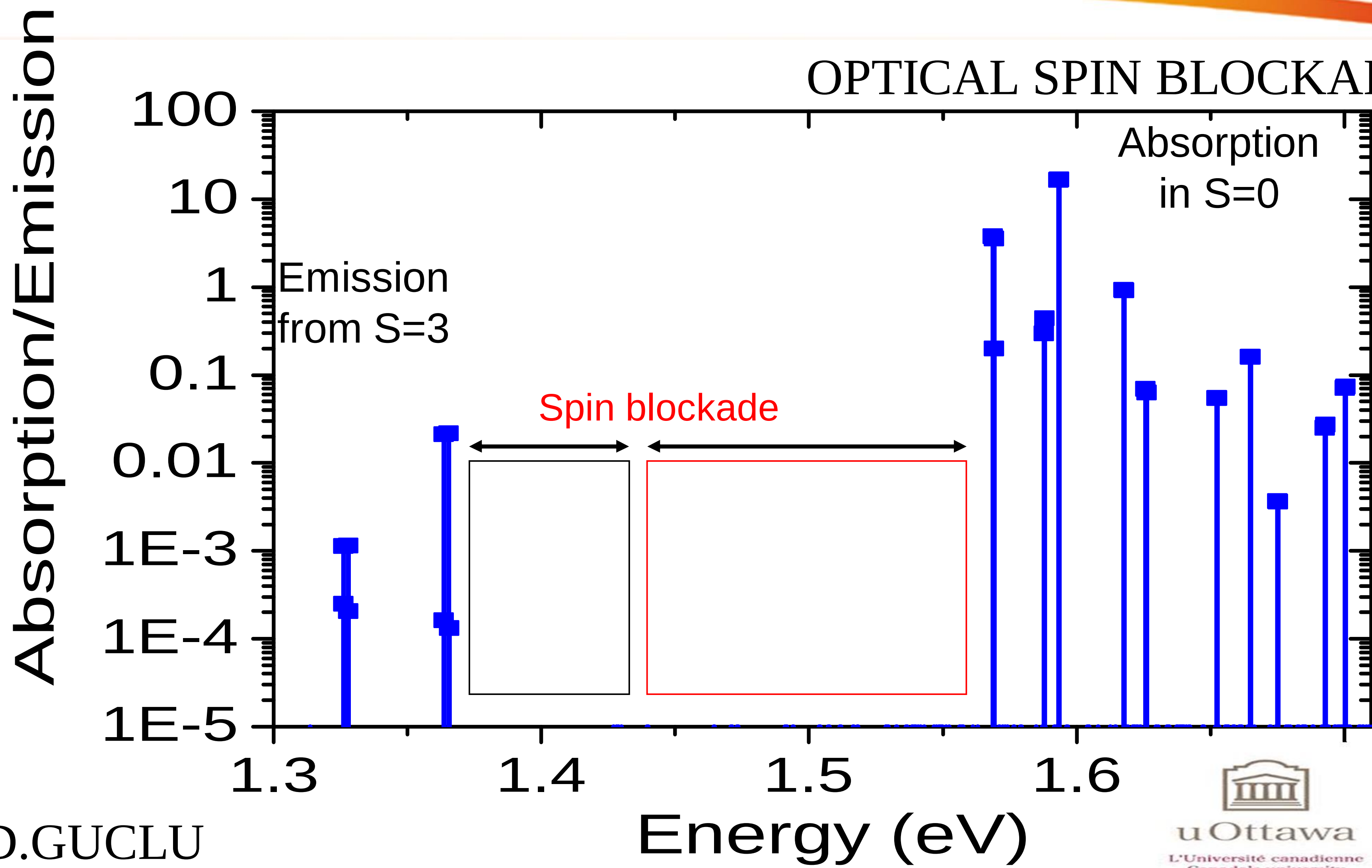
OPTICAL CONTROL OF MAGNETIC MOMENT IN GTQD
OPTICAL SPIN BLOCKADE



D.GUCLU

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SUMMARY

SCREENING IN SEMICONDUCTOR QUANTUM DOTS (cRPA)

GRAPHENE QDOTS:

BANGAP, EXCITONS AND BIEXCITONS

SUBLATTICE ENGINEERING - MAGNETIC MOMENT, ZERO ENERGY SHELL AND E-E CORRELATIONS, e-e AND VPEG IN WS2

GRAPHENE AND SEMICONDUCTOR QDOTS

ELECTRON-ELECTRON INTERACTIONS, SCREENING AND POLARIZABILITY IN SEMICONDUCTOR AND GRAPHENE QDOTS

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