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introducing the

Electromagnetic field frontier

PetaVolts per meter plasmonics *& beyond*

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large-amplitude **plasmons** – PV/m fields

Quantum gas – quasi-particle

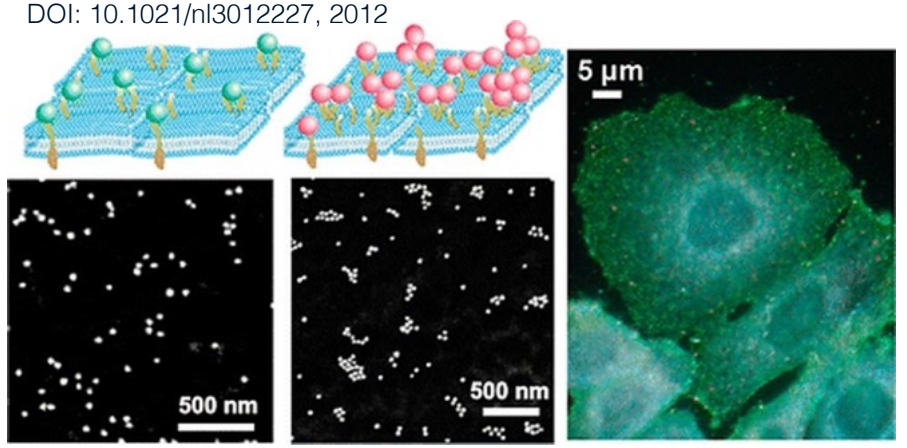
free Fermi gas - conduction band e⁻

semiconductors: $n_t \sim 10^{15\text{-}19}$ cm^{-3}
semi-metals: $n_t \sim 10^{20\text{-}22}$ cm^{-3}
metals: $n_t \sim 10^{22\text{-}24}$ cm^{-3}

roman cup

nano-imaging of biological samples

DOI: 10.1021/nl3012227, 2012



Perturbative *(conventional)*

$$\delta = \theta(2\pi)^{-1}\lambda \ll \lambda$$

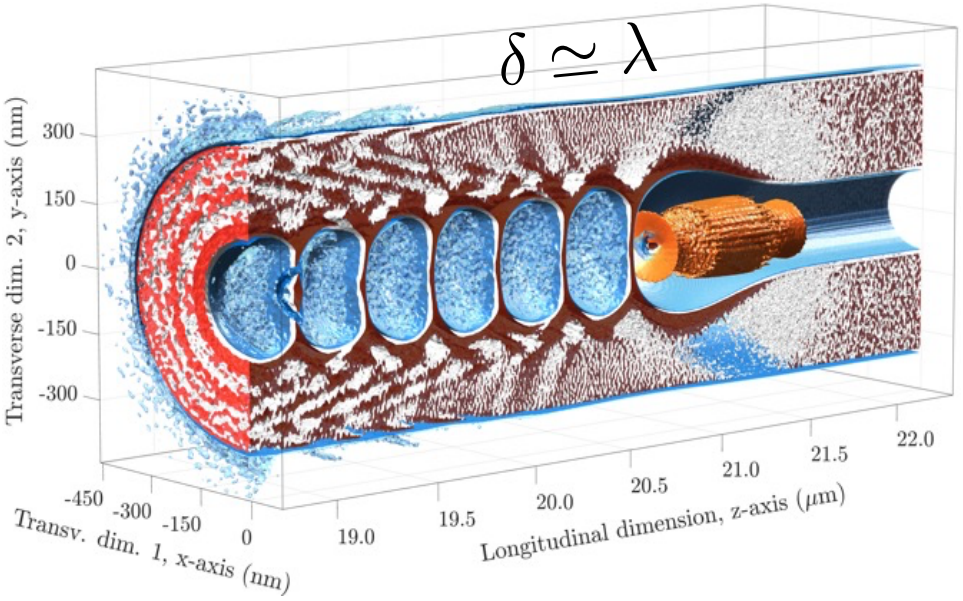
θ is angular disp. of collective e⁻ osc.

Large-amplitude plasmonics *(unexplored)*

$$\delta \simeq \lambda$$

trajectory

amplitude



Quantum coherence limit

$$\mathrm{E_p} = \frac{m_e c^2}{e}\frac{2\pi}{\lambda_{\mathrm{plasmon}}} \simeq 0.1\sqrt{n_0[10^{24}\mathrm{cm}^{-3}]}\,\mathrm{PVm}^{-1}$$

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PV/m fields – non-collider physics *(near-term)*

DO we ***WAIT for big COLLIDERs*** – for new discoveries ?
how EM field frontier – can drive discovery science

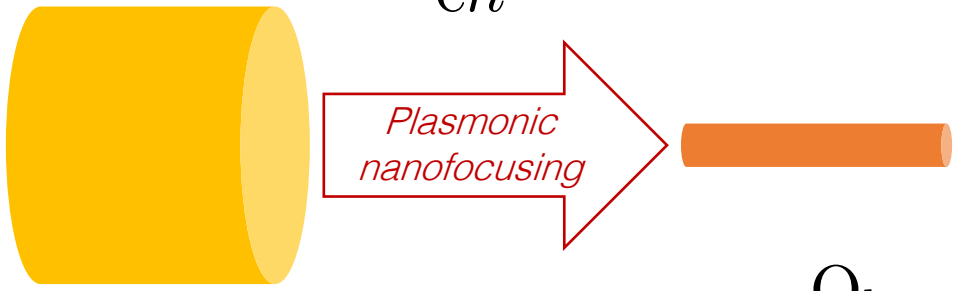
opening the vacuum

Schwinger field limit

beam-quality – NOT as critical as for colliders

E_s { extract a virtual positron-electron pair directly off of the VACUUM

$$E_s = \frac{m_e^2 c^3}{e\hbar} \sim 1.3 \times 10^{18} V/m$$



Coulomb's law
(first principles)

$$E_{bunch} \sim \frac{Q_{bunch}}{r^2}$$

probing quantum gravity

ONE electron (photon) per SHOT

Quantum gravity *(D-brane model for space–time foam)*
→ VACUUM refractive index grows with photon energy (> TeV photons *may be observable*)
→ higher energy photons – $v_p < c$
→ expected **EXCESS** delay of
>TeV energy photons in vacuum itself

no existing sources of TeV photons in the lab
data from astrophysical sources (AGN, GRB)

J. Ellis et al. / Physics Letters B 665 (2008) 412–417
Derivation of a vacuum refractive index in a stringy space–time foam model
John Ellis [a], N.E. Mavromatos [b,*], D.V. Nanopoulos [c,d,e]

EM field frontier – *snapshot of* **historical precedent**

EM field frontier

DISRUPTION in accessible EM fields ~ every 40 years

- **1980s:** Near-infrared (NIR) lasers - $\mathcal{O}(10^{12})$ **V/m**
  - CPA solid-state lasers – Strickland/Mourou (1985)
  - European Light Infra – nonlinear physics

- **1940s:** Microwave fields – $\mathcal{O}(10^{7})$ **V/m**
  - radar high-power RF pulse development – Varian / Ginzton / Hansen
  - cavity-based RF mode - convert TEM to TM

- **1900s:** DC (spark-gap) and AC field – $\mathcal{O}(10^{5})$ **V/m**
  - x-rays – Roentgen (1895) / electron – Thomson (1897)
  - Quantum mechanics / photon – Planck / Einstein (1905)
  - plasma state – Langmuir (1928)
  - Nuclear physics – proton Cyclotron – Lawrence (1930s)

requests to the committee

gas vs solid technologies – competitive evolution

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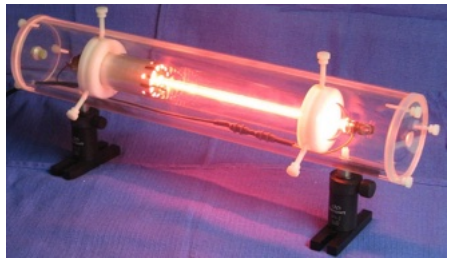
excitations in gases

excitations in solids

paradigm

discharge arc
active media
Gaseous lasers



solid-state
active media
solid-state lasers

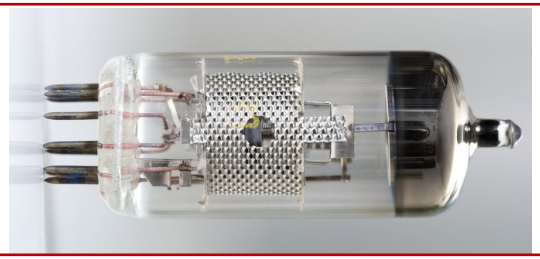
ionized gas
discharge arc
fluorescence
CFL lamps

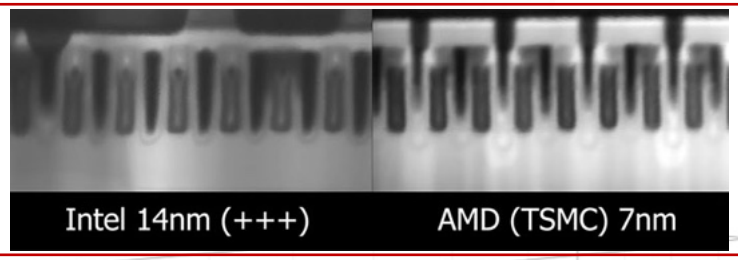
Quantum shift

solid-state
active media
LED lamps

SILICON VALLEY

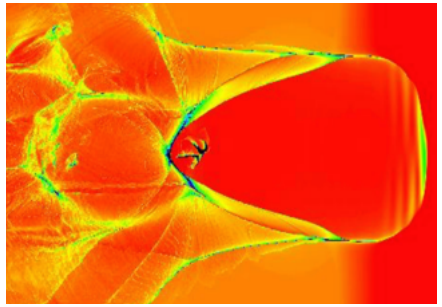
control e⁻
flow in gas
vacuum tubes

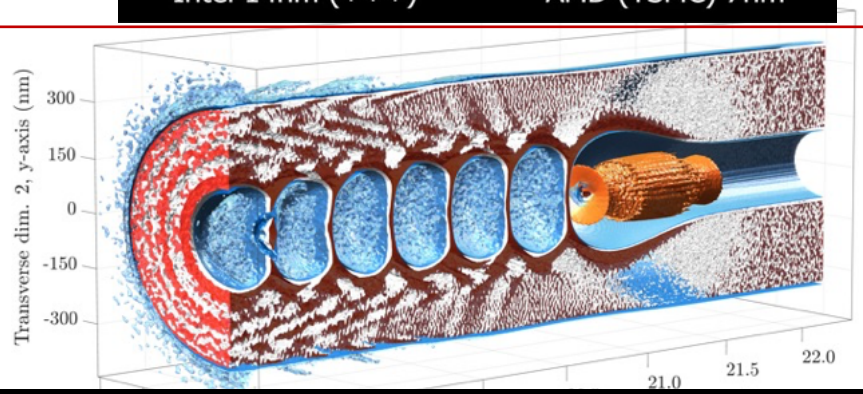




conduction e⁻ control
transistor
VLSI chip

gaseous plasma
classical e⁻ gas
plasma Acc.





Quantum e⁻ gas
new class of
plasmons

specific requests

- **Electromagnetic field frontier** for HEP – given its historicity & promise
- address **competition on key performance metrics – *against existing efforts***
- national user facilities – "open" mandate – based on ***scientific merit***
- ***funding for prototyping*** – **$1 – 2.5M** (multi-year)
- ***funding for workshops and meetings*** - gather the "scattered" community