On the theory of Electron Glass

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Historical Introduction

1. Term:Davies, Lee, Rice (1982,1984)
2. C. J Adkins (granular gold film,1984);
3. Z. Ovadyahu group(InO,1993 and later);
4. A. M. Goldman group (Ultrathin films of Pb and Bi,1997,1998)
5. T. Grenet (granular aluminum films, 2003 and later)

Historical Introduction, Theory

1. Extrinsic Mechanism (Burin, Galperin, Vinokur)
2. Intrinsic Mechanism (Burin et al)
3. Eigen values of the random matrixes (group of Joseph Imry)

Standart model

$$H = \sum n_i \phi_i + 1/2 \sum_{i \neq j} (n_i - 1/2)(n_j - 1/2) e^2 / r_{ij}$$

$$-D < \phi < D; n_i = \pm 1$$

$$A = \frac{D}{e^2 / l} >> 1; g_0 = 1/2 D l^3$$

$$\delta H / \delta n_i = \varepsilon_i = \phi_i + \sum_{j \neq i} (n_j - \frac{1}{2}) e^2 / r_{ij}$$

First Conditions of stability:

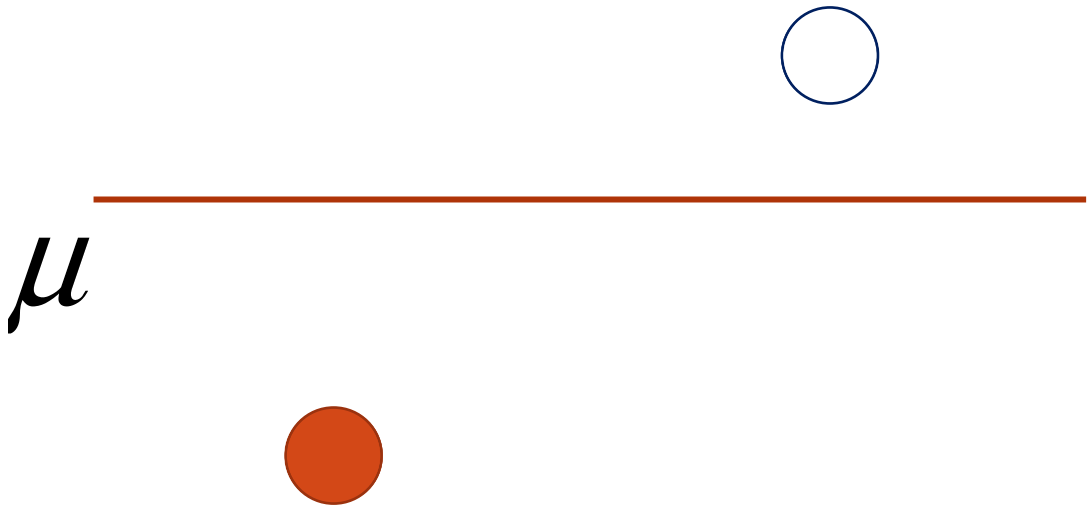
1.

$n_i = 1$

$if\ \varepsilon_i < \mu$

$n_i = -1$

$if\ \varepsilon_i > \mu$



Second condition of stability

$$\Omega_{ij} = \varepsilon_j - \varepsilon_i - e^2 / r_{ij} > 0$$

$$g(\varepsilon) = \frac{3}{\pi} \varepsilon^2 / e^6$$

Absence of screening of the point charge.

$$\rho(T) = \rho_0 \exp(\frac{T_0}{T})^{1/2}$$

Width of the Coulomb Gap

$$g(\Delta) = g_0 \qquad g(\varepsilon) = \frac{3}{\pi}\varepsilon^2 / e^6$$

$$\Delta = (g_0 e^6)^{1/2}$$

The role of the width

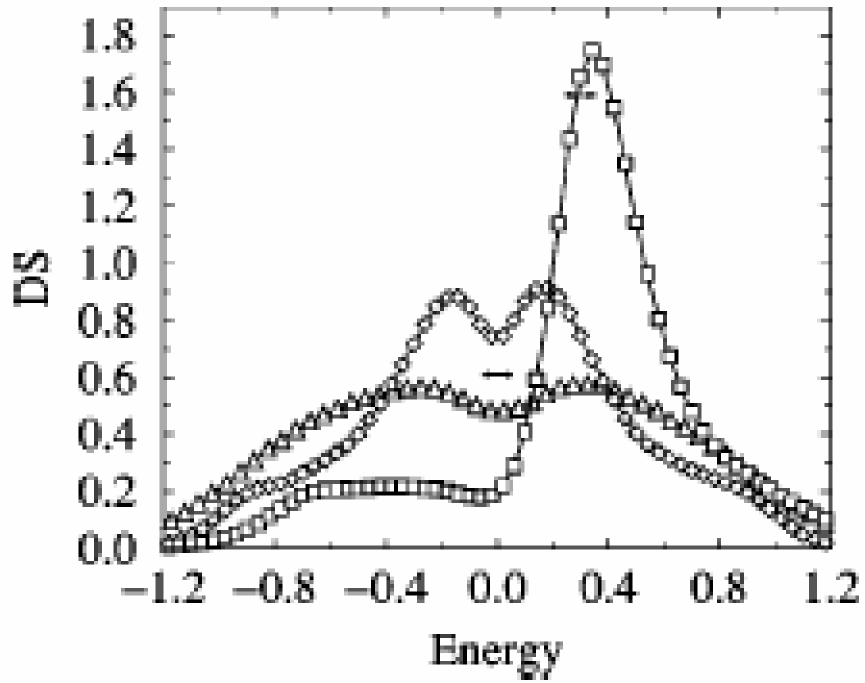


FIG. 5. Final energy distribution of sites initially in the energy range $[E_c-W, E_c+W]$. Diamonds (◇) are for $E_c=0$, $W=0.05$, $T=0.05$. Sqaures (□) are for $E_c=0.3$, $W=0.1$, $T=0.05$. Triangles (△) are for $T=0.1$, $E_c=0$ and $W=0.05$. The arrows mark the positions and widths of the two initial distributions of test sites which were used. All results are for $A=1$.

Menashe et al PRB 2001

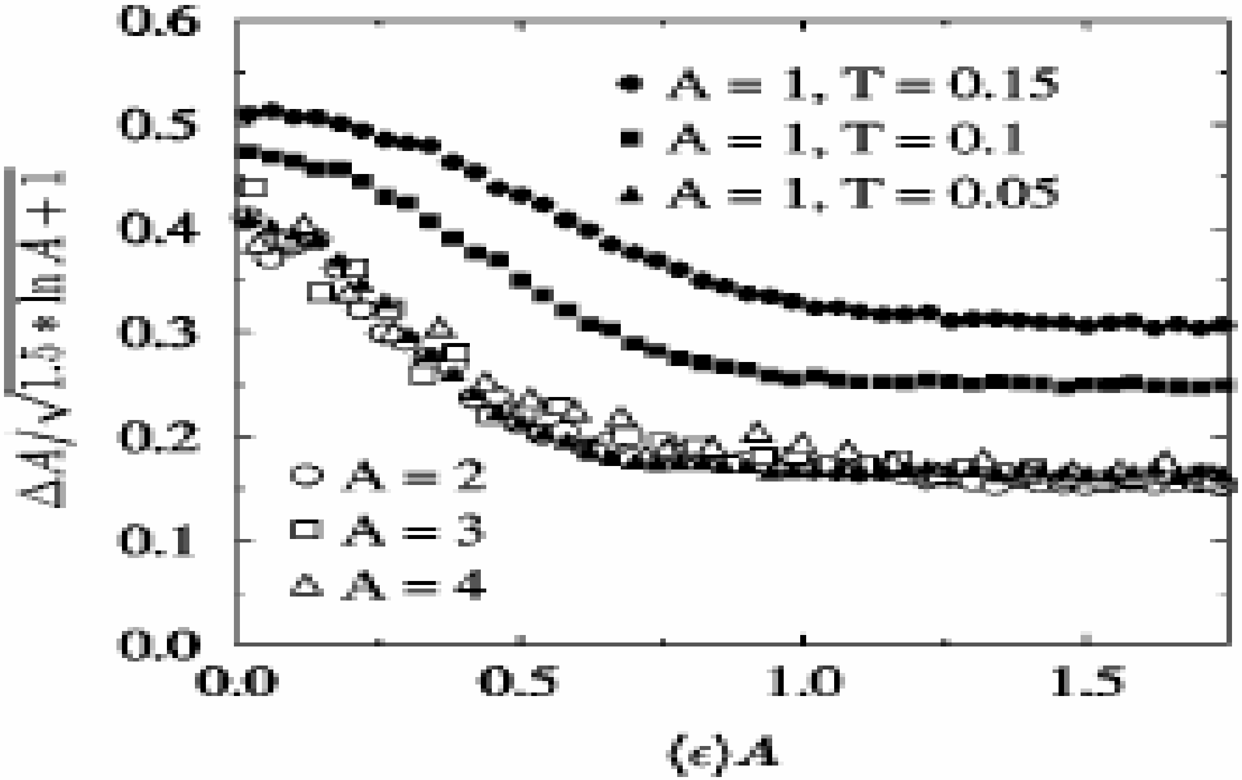


FIG. 6. Site energy standard deviation as a function of site average energy $\Delta(\langle\epsilon\rangle)$, for various values of A and T. For $A>1$ the temperature is given by $T=0.05/A$, and we used a system size of $L=200$, and a number of disorder realizations $P=20$. Only possitive energies are shown due to particle hole symmetry.

Menashe et al PRB 2001

Only the sites inside the gap change their occupation when the system travels from one pseudoground state to the other. **Thus, they are the keepers of the memory if disorder is larger than nearest neighbor interaction.**

MOTT' s CASE NO Memory!!!!!!

Dipole excitations

$$\Omega_{ij} = \varepsilon_j - \varepsilon_i - e^2 / r_{ij} > 0$$

If potentials created by other sites at 1 and 2 are the same, $\Omega_{21} = 0$

$$\varepsilon_2 = -\frac{1}{2}\frac{e^2}{r_{12}}$$

$$\Omega_{21} = \varepsilon_1 - \varepsilon_2 - e^2 / r_{ij} = 0$$

$$\varepsilon_1 = \frac{1}{2}\frac{e^2}{r_{12}}$$

Polarization catastrophe

$$F(\Omega) = g_0$$

$$\Delta^2 = e^6 g_0$$

$$e^2 g_0 r_0^2 = 1$$

$$r_0 = e^2 / \Delta$$

Number of dipoles with excitation energy less than eEr_0

$$N = \frac{2}{\pi} eEr_0 g_0 r^3$$

$$P = Ner_0 / r^3 = E$$

Polarization catastrophe

$$P = \chi_0 E$$

$$\chi_0 = 2/\pi$$

$$\chi = \frac{\chi_0}{1-(4\pi/3)\chi_0} = \frac{\chi_0}{1-8/3}$$

Interaction of dipoles

Depending on angles dipole-dipole interaction may have NEGATIVE energy.

Average distance between dipoles dipoles with excitation energy less than Ω

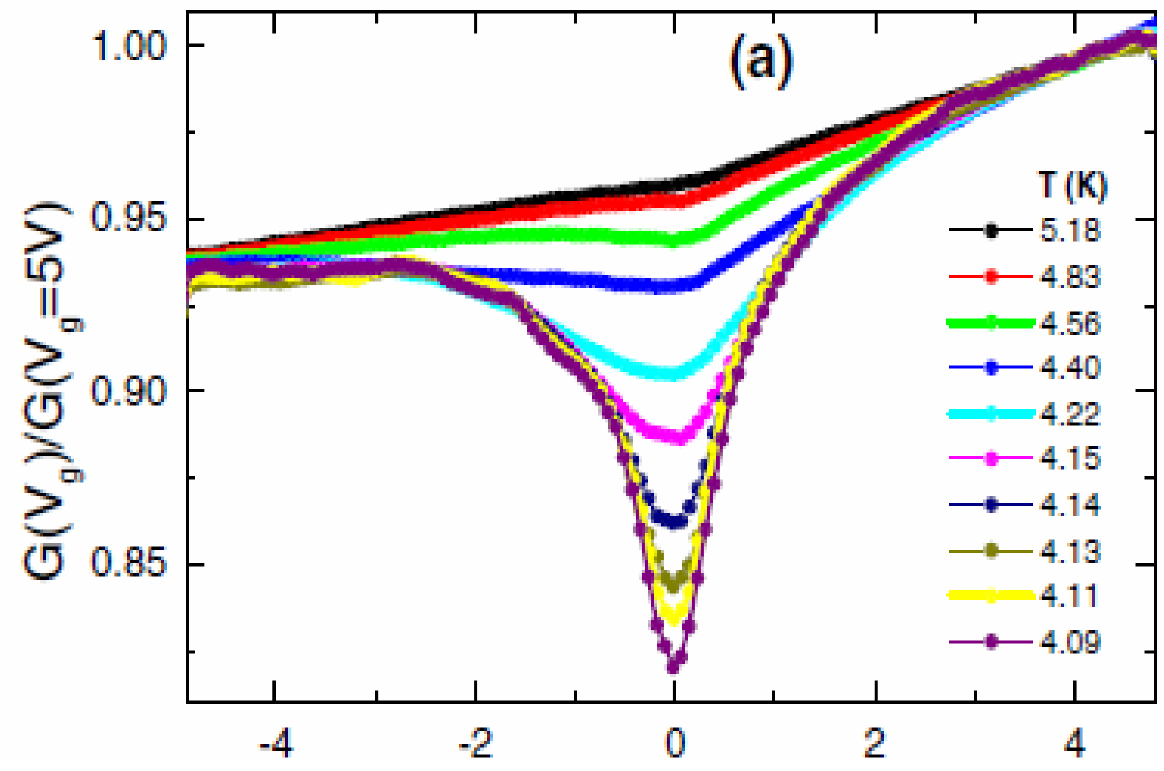
Can be found from the condition

$$g_0 \Omega r_a^3 = 1 \qquad r_a = 1/(g_0 \Omega)^{1/3}$$

Interaction energy of dipoles $e^2 r_0^2 / r_a^3 = \Omega$

Polarization catastrophe means that random and non-correleted distribution of the dipoles is uinstable. Thus I think that they should form a dipole glass

Memory dip (Ovadyahu 2008)



The width of the dip

New electrons (or holes) should be able to organize a new network.
For ES transport the energy width of this network W

$$W = (TT_0)^{1/2}$$

The density of the new electrons is

$$n = \int_0^W g(\varepsilon)\, d\varepsilon = \frac{T}{e^2 \xi}$$

CONCLUSIONS

1. I believe that the glass effect in localized electron liquid can exist, and it is connected with formation of the dipole glass.

2. The CG often mentioned in connection with this effect places two-fold role:

a. The occupation of the sites above the the CG are independent of the interaction.

b. CG is important for the VRH while the VRH is the common way to observe glassy effects.

3. There should be a way to detect glassy effects without hopping conductivity.