ANDRZEJ DRAGAN / WARSAW

FILIP KIAŁKA / VIENNA (Ł = $\frac{L}{2\pi}$)

ALEX SMITH / WATERLOO

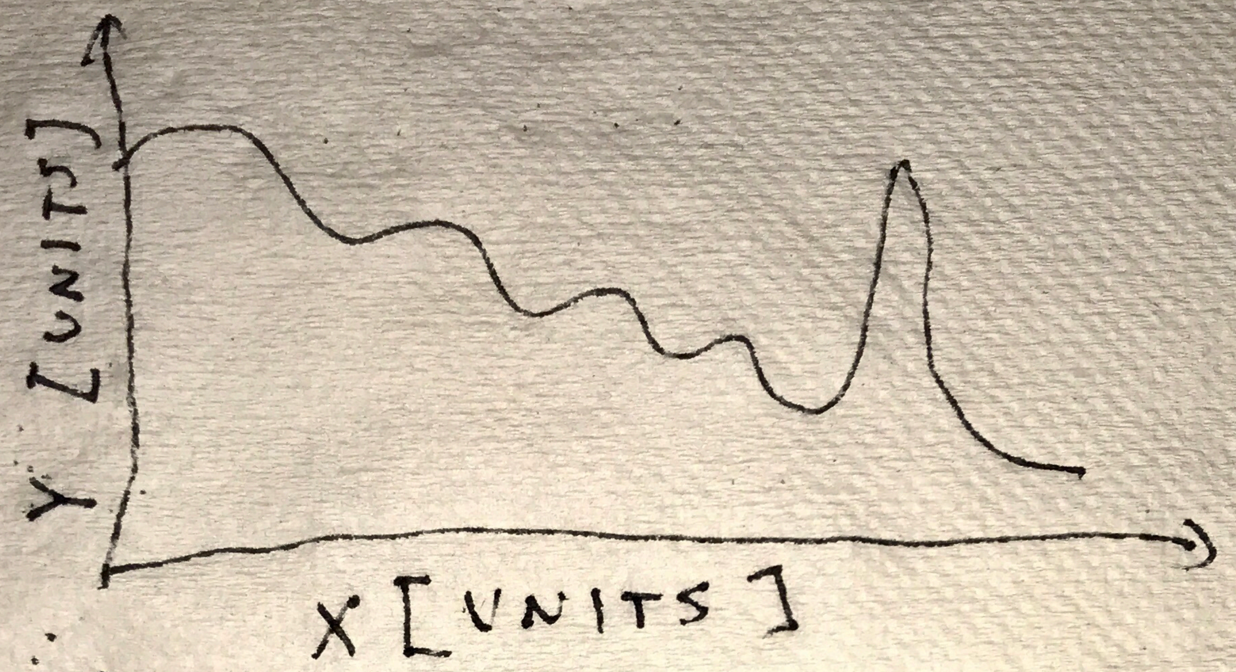
MEHD AHMADI / CALGARY

ABSTRACT

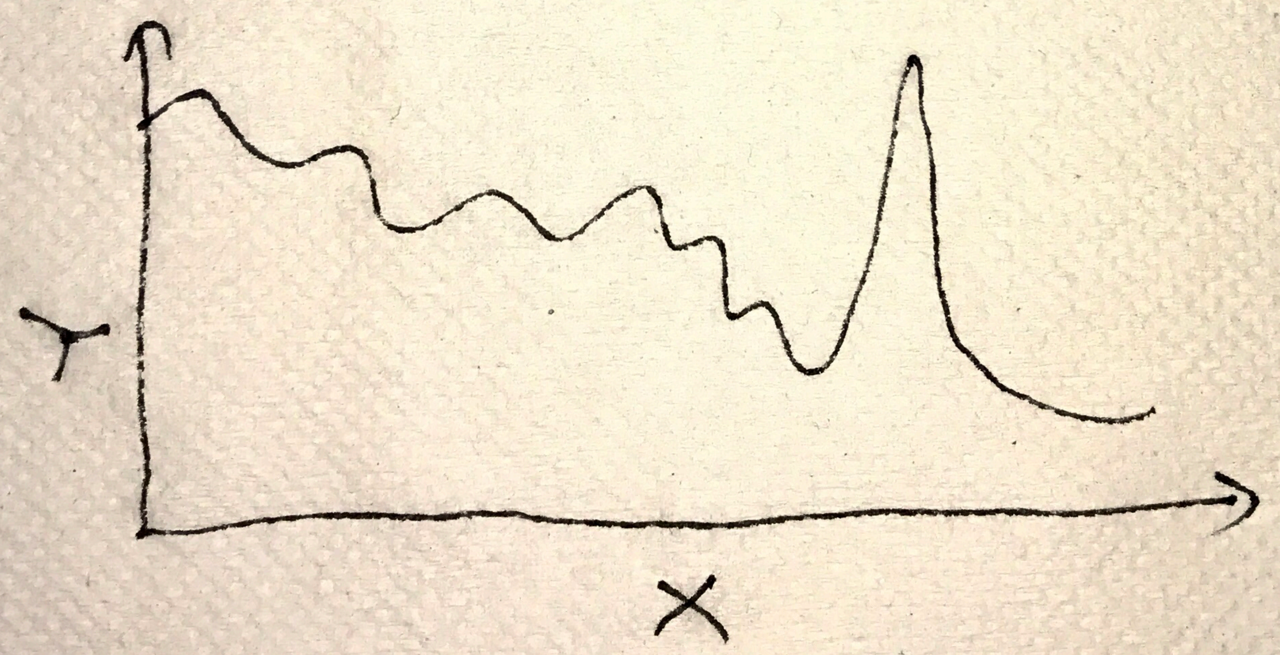
THE UNRUH EFFECT FOR MASSIVE FIELDS WILL NOT BE MEASURED.

MASSIVE UNRUH PARTICLES CAN ONLY BE FOUND IN A TINY LAYER ABOVE THE EVENT HORIZON THAT IS ONLY COMPTON WAVELENGTH THIN.

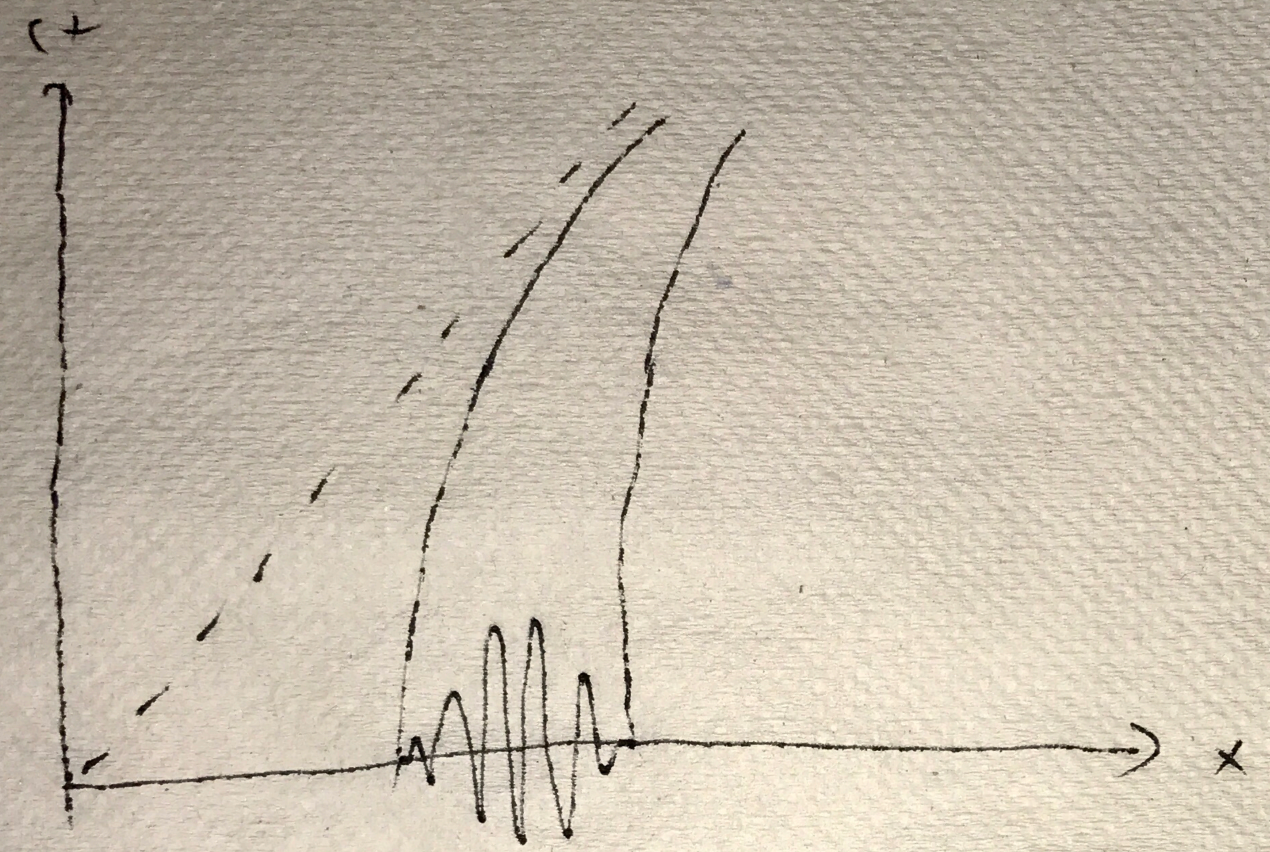
A TYPICAL PLOT IN A PHYSICS PAPER:



A TYPICAL PLOT IN AN RQI PAPER:



WITHIN A SINGLE WAVEPACKET:



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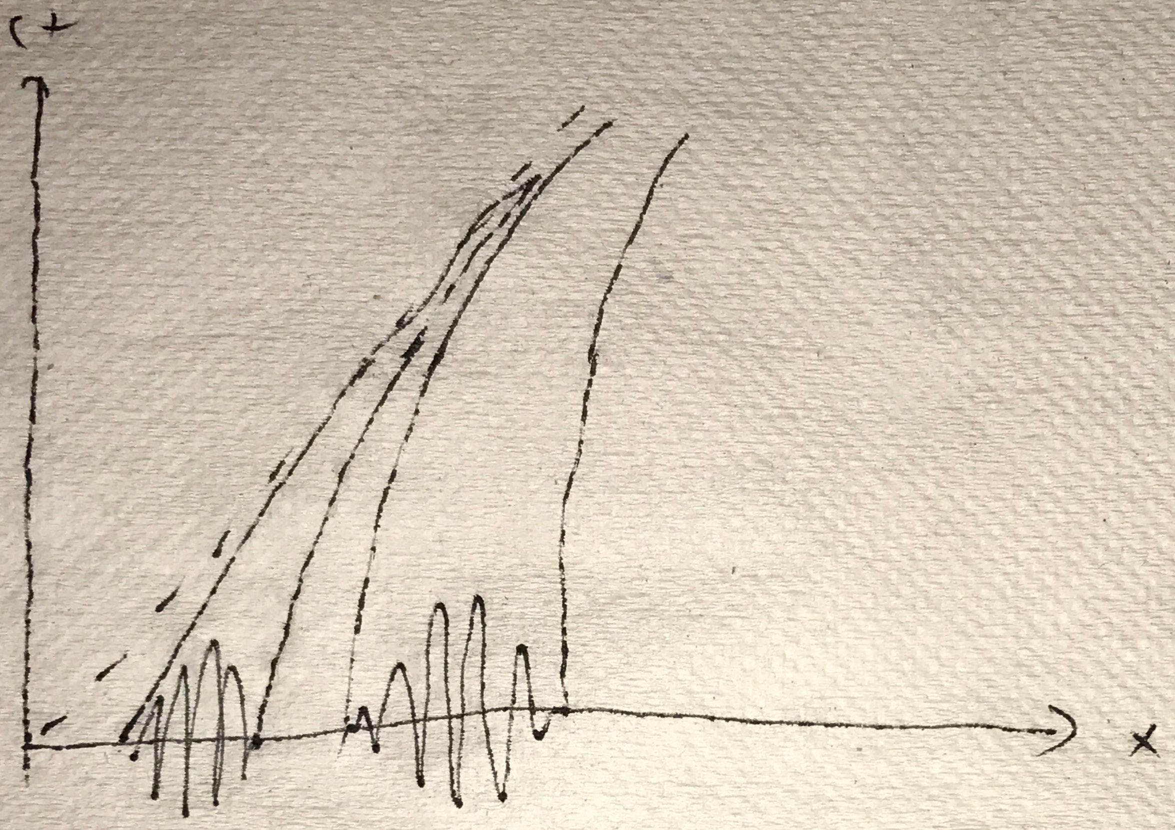
Restoring the powers of $\hbar, c$, gives $a_1 \gtrsim mc^3/\hbar$, which

WITHIN A SINGLE WAVEPACKET:



HOW MANY UNRUH PARTICLES

CAN BE FOUND IN A 1 m³ BOX?

$$\hat{\phi}^+ \equiv \int d^3k \; u_k \, \hat{a}_k$$

$$\hat{N} \equiv \int d^3k \; \hat{a}^\dagger_k \, \hat{a}_k$$

MANDEL:

$$\hat{A} \equiv \int d^3k \sqrt{2\omega_k} \, u_k \, \hat{a}_k$$

$$N_1(V) \equiv \int_V d^3x \; \hat{A}^\dagger \hat{A}$$

$$u_k \rightarrow w_k \,, \quad \omega_k \rightarrow \Omega \quad \hat{a}_k \rightarrow \hat{b}_k$$

IN PARTICULAR: $\hat{N}_1(\mathbb{R}^3) = \hat{N}$

BUT SUCH CONSTRUCTION ISN'T UNIQUE.

$$\hat{N} = \int d^3k \; a_k^\dagger a_k = \int d^3k \left(\hat{\phi}^+, u_k\right)\left(u_k, \hat{\phi}^+\right)$$

$$= \left(\hat{\phi}^+, \hat{\phi}^+\right) = \int d^3x \; i \hat{\phi}^- \overleftrightarrow{\partial_t} \hat{\phi}^+$$

WHICH SUGGEST ANOTHER DEFINITION:

$$\hat{N}_2(V) \equiv \int_V d^3x \; i \hat{\phi}^- \overleftrightarrow{\partial_t} \hat{\phi}^+.$$

ALSO: $\hat{N}_2(\mathbb{R}^3) = \hat{N}$.

EASY TO GENERALIZE.

$t \to \tau$, $\pm$ MINKOWSKI $\to$ $\pm$ RINDLER

MOREOVER, $\hat{N}_1(V) = \hat{N}_2(V) \quad \forall\, |\psi\rangle$:

$$\langle\psi|\, \hat{b}^{+}_{\Omega}\, \hat{b}_{\Omega'}\, |\psi\rangle \sim \delta(\Omega - \Omega')$$

TAKE A $1\,m^3$ ACCELERATING BOX

$$ {}_M\langle 0|\hat{N}_2(v)|0\rangle_M = \frac{S_\perp}{2\pi^3}\int d\Omega\, dk_\perp\, k_\perp \tilde{\Omega}\, e^{-\pi\Omega} \times \int_{\chi_1}^{\chi_2} \frac{d\chi}{\chi} K^2_{i\Omega}\left(\sqrt{k_\perp^2+m^2}\,\chi\right). $$

$\Omega \gg 1$ DO NOT CONTRIBUTE

W $\Omega \lesssim 1 \Rightarrow \forall x > 1 \; K^2_{i\Omega}(x) \simeq 0.$

$$ \Rightarrow 1 \gtrsim \sqrt{k_\perp^2+m^2}\,\chi \geqslant m\chi $$

$$ \Rightarrow \chi \lesssim \frac{\hbar}{mc} = \lambda_c $$

$$\Rightarrow \quad x \lesssim \frac{\hbar}{mc} = \lambda_c$$

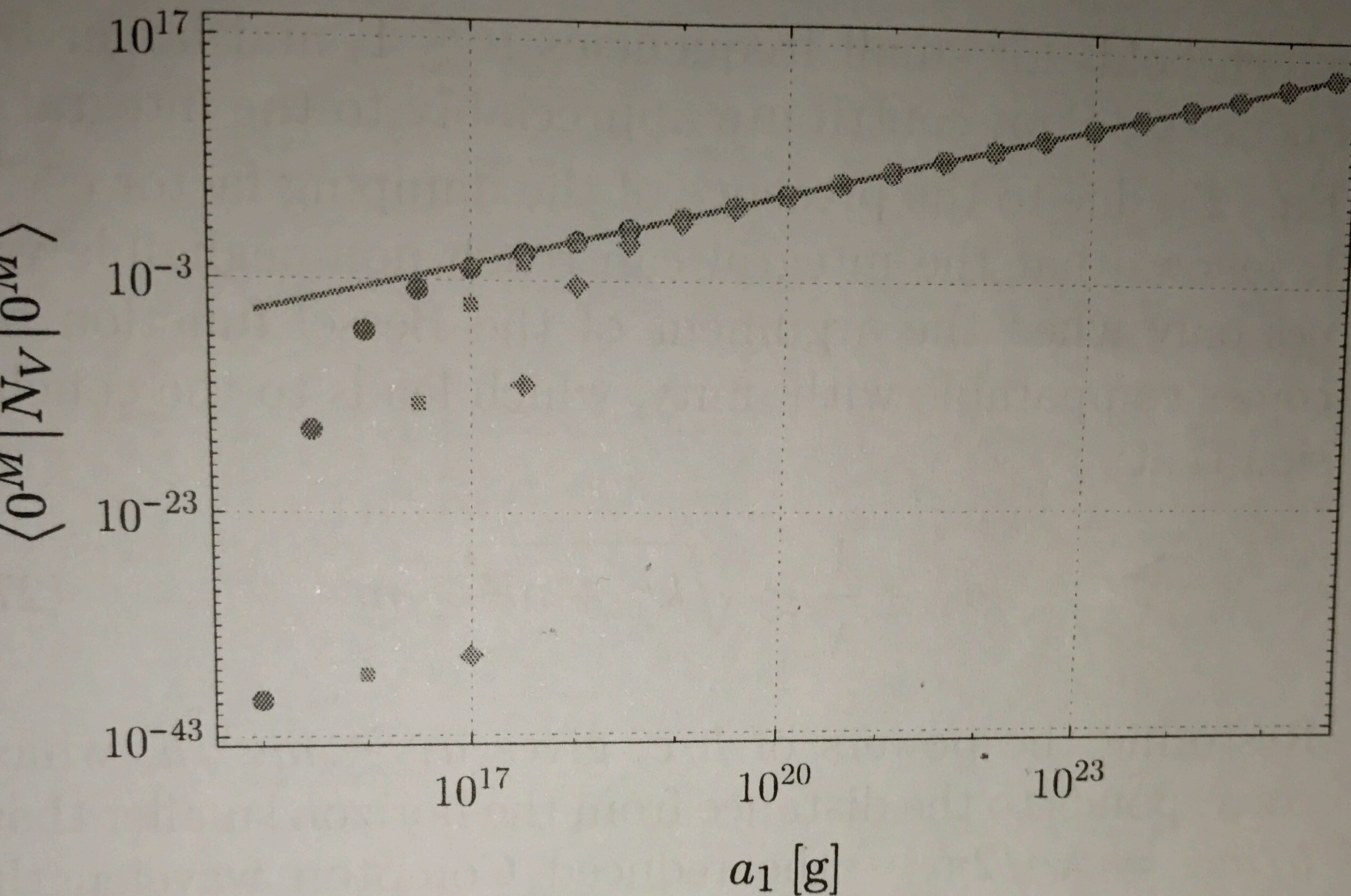


FIG. 2. Average number of massive Unruh particles in a $1\,\mathrm{m}^3$ box as a function of its proper acceleration. The field mass is $m = 10^{-11}\, m_e$ (dots), $m = 10^{-10}\, m_e$ (squares), and $m = 10^{-9}\, m_e$ (diamonds), corresponding to Compton wavelengths $\lambda_C \approx 0.2\,\mathrm{m}$, $\lambda_C \approx 0.02\,\mathrm{m}$, and $\lambda_C \approx 0.002\,\mathrm{m}$, respectively. The continuous line is the high-acceleration limit given by Eq. (35) and (36).

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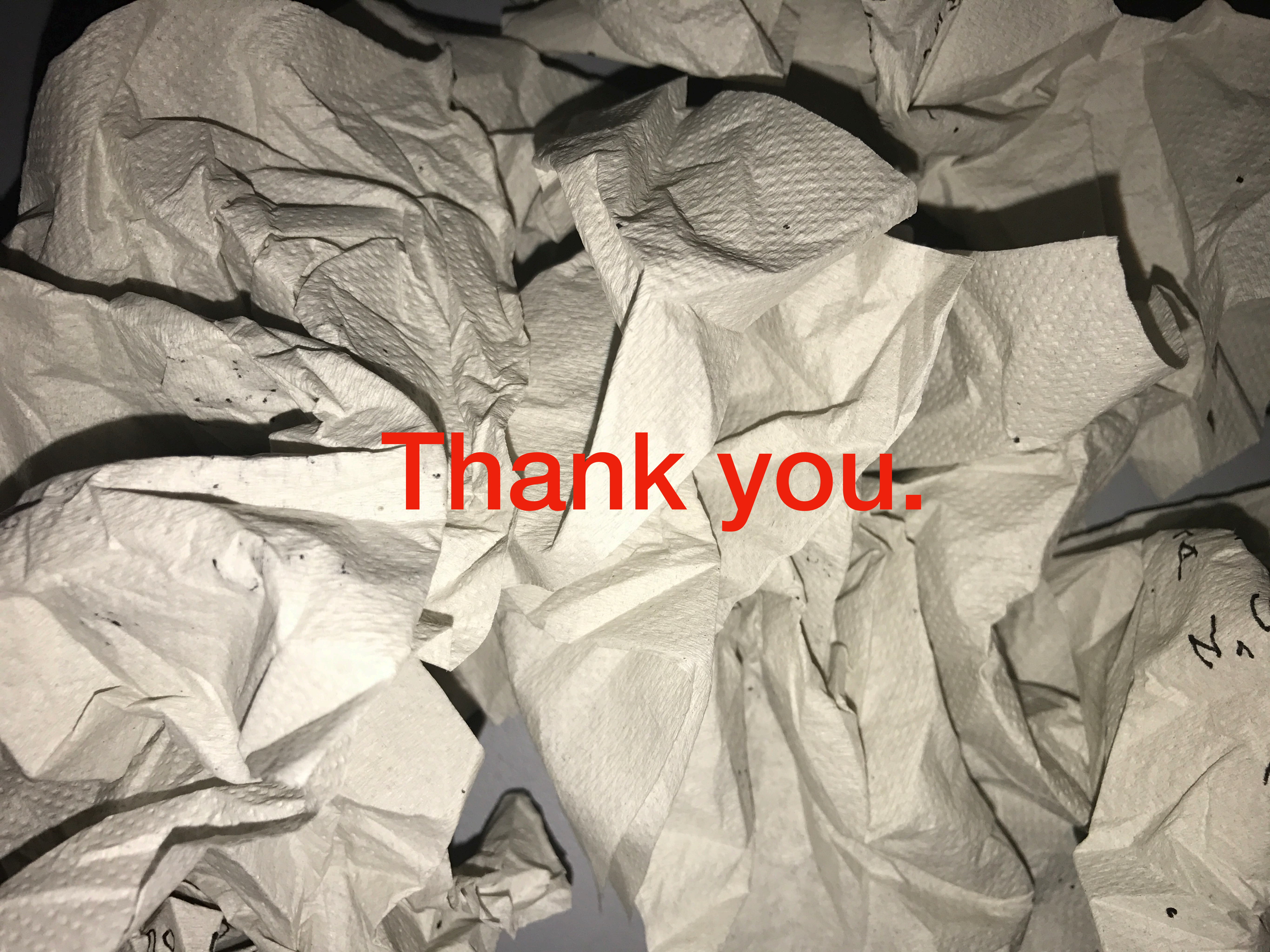
Thank you.