

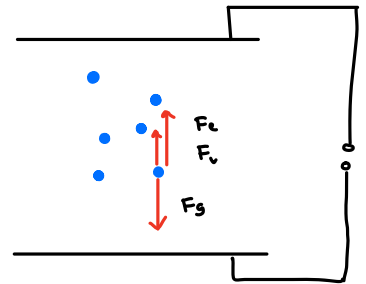
# Določitev osnovnega naboja po Millikanu

## 1 Teorija

Na neutrano kapljico delujejo sile tež, vzgona in upora ter velja

$$\frac{4\pi}{3} r^3 (\rho - \rho_{\text{zr}}) g = 6\pi r \eta v$$

$$\Rightarrow r^2 = \frac{9 \eta v}{2(\rho - \rho_{\text{zr}}) g}$$



Ob prisotnosti električnega polja velja naslednja rovnovesna enačba

$$\frac{4\pi}{3} r^3 (\rho - \rho_{\text{zr}}) g = n e_0 \frac{U}{d}$$

od koder lahko določimo  $n e_0$ . Z določitvijo  $e_0$  izvedemo poskus, ko kapljice potujejo s konstantno hitrostjo, tedaj velja

$$\frac{4\pi}{3} r^3 (\rho - \rho_{\text{zr}}) g + |n| e_0 E = 6\pi r \eta v_+$$

$$\frac{4\pi}{3} r^3 (\rho - \rho_{\text{zr}}) g - |n| e_0 E = -6\pi r \eta v_-$$

enosti odštejemo in sestavimo tri doline

$$r^2 = \frac{9 \eta (v_+ - v_-)}{4 g (\rho - \rho_{\text{zr}})}$$

$$|n| e_0 = \frac{3\pi r \eta}{E} (v_+ + v_-)$$

## 2 Rezultati

Podatki

$$d = 5 \text{ mm } (1 \pm 2\%)$$

$$\rho = 973 \text{ kg/m}^3$$

$$\rho_{\text{zr}} = 1,17 \text{ kg/m}^3$$

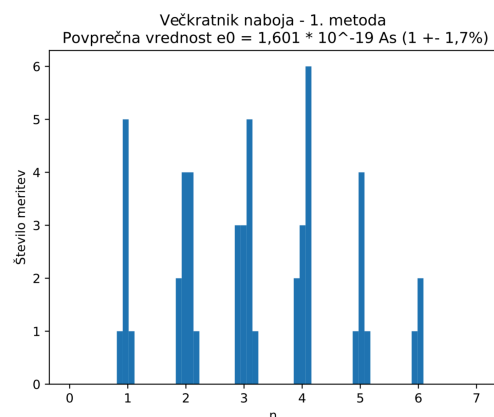
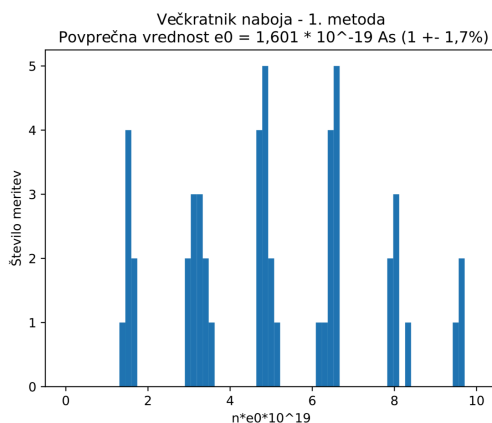
$$g = 9,81 \text{ m/s}^2$$

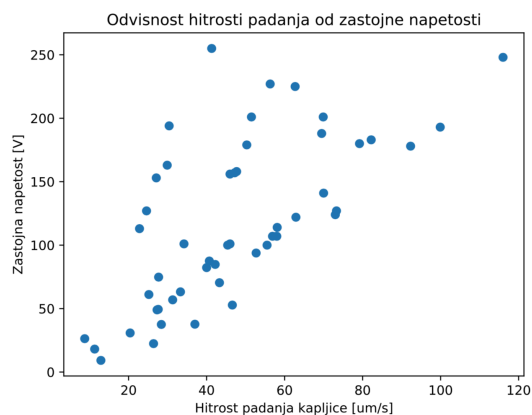
$$\eta = 1,827 \cdot 10^{-5} \text{ Pa s}$$

Z uporabo zgornjih enačb in znanih konstant lahko izračunamo  $r^2$  in  $n e_0$  za vsako uimer.

Če dan enačbo uporabimo na uimer s 1. metodo lahko ugotovimo, da je povprečna vrednost osnovnega el. naboja

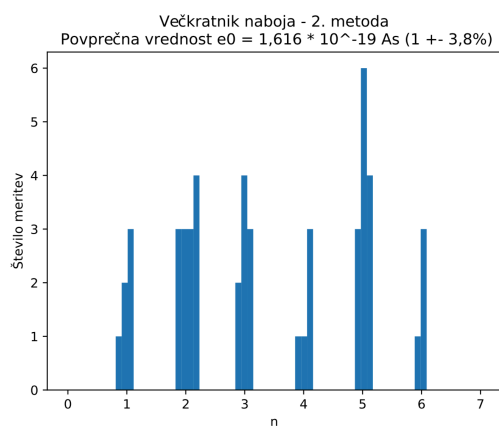
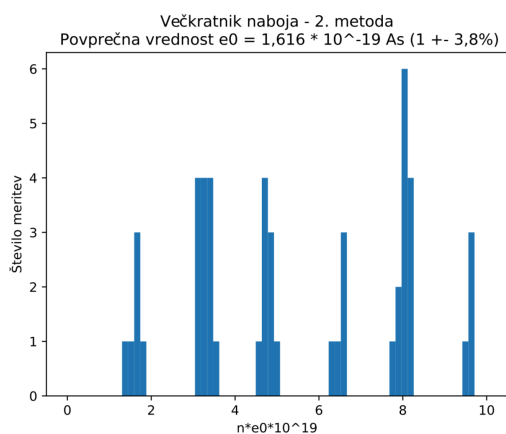
$$e_0 = 1,601 \cdot 10^{-19} \text{ As } (1 \pm 1,7\%)$$





Pri čemer smo napako ocenili iz standardne deviacije meritev. Realna vrednost  $e_0$  je znotraj napake meritev. Napake so posledica končne ločljivosti merilnih naprav.

Kot zanimivost lahko pogledamo odvisnost zapore napetosti od hitrosti padanja kapljice, kjer lahko opazimo linearno odvisnost. Naklon krivke je odvisen od števila nabojev.



Z uporabo 2. metode dobimo, da je  $\langle e_0 \rangle$

$$e_0 = 1,616 \cdot 10^{-19} \text{ As} (1 \pm 3,8\%)$$

kjer vrednost prav tako odstopa v okviru napake od prave vrednosti.

Višjo napako 2. metode lahko pojasnimo z višjo napako merjenja hitrosti.

Na zadnji strani sta priloženi tabeli, kjer je uveden polmer,  $u_{e0}$  in  $u_z$  v sili meritev.

Meto da 1

v	U	r <sup>2</sup>	ne0	n
2,28E-05	113	1,97E-13	1,54E-19	1
2,99E-05	163	2,58E-13	1,6E-19	1
4,13E-05	255	3,56E-13	1,66E-19	1
8,75E-06	26,3	7,55E-14	1,57E-19	1
3,04E-05	194	2,62E-13	1,38E-19	1
2,71E-05	153	2,34E-13	1,47E-19	1
2,46E-05	127	2,12E-13	1,54E-19	1
5,03E-05	179	4,34E-13	3,19E-19	2
4,72E-05	157	4,07E-13	3,3E-19	2
3,42E-05	101	2,95E-13	3,17E-19	2
6,27E-05	225	5,41E-13	3,53E-19	2
5,15E-05	201	4,44E-13	2,94E-19	2
2,52E-05	61,1	2,17E-13	3,31E-19	2
1,13E-05	18,1	9,74E-14	3,36E-19	2
5,63E-05	227	4,86E-13	2,98E-19	2
2,77E-05	74,8	2,39E-13	3,12E-19	2
4,77E-05	158	4,11E-13	3,33E-19	2
0,000046	156	3,97E-13	3,2E-19	2
0,000046	101	3,97E-13	4,94E-19	3
2,76E-05	49,4	2,38E-13	4,69E-19	3
6,99E-05	201	6,03E-13	4,65E-19	3
2,04E-05	30,8	1,76E-13	4,78E-19	3
4,54E-05	100	3,92E-13	4,89E-19	3
4,07E-05	87,5	3,51E-13	4,75E-19	3
4,22E-05	84,8	3,64E-13	5,17E-19	3
3,33E-05	63,2	2,87E-13	4,86E-19	3
2,73E-05	49	2,35E-13	4,65E-19	3
0,00004	82,3	3,45E-13	4,92E-19	3
6,95E-05	188	5,99E-13	4,93E-19	3
3,13E-05	56,9	2,7E-13	4,92E-19	3
0,00007	141	6,04E-13	6,64E-19	4
4,33E-05	70,4	3,73E-13	6,47E-19	4
6,29E-05	122	5,42E-13	6,54E-19	4
5,27E-05	93,8	4,54E-13	6,52E-19	4
5,55E-05	100	4,79E-13	6,61E-19	4
0,000058	107	5E-13	6,6E-19	4
8,22E-05	183	7,09E-13	6,51E-19	4
2,84E-05	37,5	2,45E-13	6,45E-19	4
5,81E-05	114	5,01E-13	6,21E-19	4
7,92E-05	180	6,83E-13	6,26E-19	4
5,69E-05	107	4,91E-13	6,41E-19	4
9,99E-05	193	8,62E-13	8,27E-19	5
0,000073	124	6,3E-13	8,04E-19	5
9,23E-05	178	7,96E-13	7,97E-19	5
0,000116	248	1E-12	8,06E-19	5
1,29E-05	9,19	1,11E-13	8,06E-19	5
7,33E-05	127	6,32E-13	7,9E-19	5
2,64E-05	22,4	2,28E-13	9,68E-19	6
4,66E-05	52,8	4,02E-13	9,63E-19	6
0,000037	37,7	3,19E-13	9,55E-19	6

Meto da 2

v+	v-	r <sup>2</sup>	ne0	n	e0
6,75E-05	4,61E-06	2,71E-13	1,62E-19	1	1,62E-19
6,57E-05	2,64E-05	1,69E-13	1,63E-19	1	1,63E-19
7,05E-05	8,68E-07	3E-13	1,68E-19	1	1,68E-19
7,2E-05	5,68E-05	6,56E-14	1,42E-19	1	1,42E-19
7,28E-05	1,24E-06	3,09E-13	1,77E-19	1	1,77E-19
6,37E-05	0,000023	1,76E-13	1,56E-19	1	1,56E-19
0,000109	7,35E-05	1,52E-13	3,05E-19	2	1,53E-19
0,000103	3,92E-05	2,77E-13	3,23E-19	2	1,61E-19
0,000111	9,8E-06	4,35E-13	3,42E-19	2	1,71E-19
0,000106	1,8E-05	3,8E-13	3,29E-19	2	1,65E-19
0,000118	8,12E-05	1,59E-13	3,43E-19	2	1,71E-19
9,96E-05	3,24E-05	2,9E-13	3,06E-19	2	1,53E-19
0,000106	3,17E-05	3,2E-13	3,35E-19	2	1,68E-19
0,000104	3,02E-05	3,17E-13	3,24E-19	2	1,62E-19
0,000105	3,41E-05	3,05E-13	3,3E-19	2	1,65E-19
0,000109	3,51E-05	3,19E-13	3,51E-19	2	1,75E-19
0,000112	7,67E-05	1,53E-13	3,19E-19	2	1,59E-19
0,000109	4,84E-05	2,62E-13	3,47E-19	2	1,73E-19
9,96E-05	3,74E-05	2,68E-13	3,05E-19	2	1,53E-19
0,000134	6,13E-05	3,15E-13	4,72E-19	3	1,57E-19
0,000141	2,47E-05	5E-13	5,03E-19	3	1,68E-19
0,000136	4,73E-05	3,84E-13	4,9E-19	3	1,63E-19
0,000143	2,56E-06	6,07E-13	4,89E-19	3	1,63E-19
0,000131	6,04E-05	3,05E-13	4,56E-19	3	1,52E-19
0,000136	6,53E-05	3,04E-13	4,78E-19	3	1,59E-19
0,000135	7,1E-05	2,76E-13	4,66E-19	3	1,55E-19
0,000135	5,71E-05	3,36E-13	4,8E-19	3	1,6E-19
0,000137	1,4E-05	5,29E-13	4,72E-19	3	1,57E-19
0,000175	9,3E-07	7,51E-13	6,57E-19	4	1,64E-19
0,000163	6,03E-05	4,45E-13	6,42E-19	4	1,61E-19
0,000169	2,82E-05	6,07E-13	6,62E-19	4	1,65E-19
0,0002	0,000162	1,63E-13	6,28E-19	4	1,57E-19
0,000194	0,000148	2E-13	6,6E-19	4	1,65E-19
0,000205	0,000136	3,01E-13	8,05E-19	5	1,61E-19
0,000193	9,23E-05	4,35E-13	8,11E-19	5	1,62E-19
0,000198	9,31E-06	8,15E-13	8,07E-19	5	1,61E-19
0,0002	1,06E-05	8,15E-13	8,17E-19	5	1,63E-19
0,000196	0,000101	4,11E-13	8,19E-19	5	1,64E-19
0,000187	4,48E-05	6,13E-13	7,81E-19	5	1,56E-19
0,000208	0,000139	2,97E-13	8,15E-19	5	1,63E-19
0,000188	6,81E-05	5,16E-13	7,9E-19	5	1,58E-19
0,000201	5,56E-06	8,45E-13	8,19E-19	5	1,64E-19
0,000191	6,4E-05	5,47E-13	8,11E-19	5	1,62E-19
0,000192	3,73E-05	6,66E-13	8,05E-19	5	1,61E-19
0,000193	2,19E-05	7,36E-13	7,92E-19	5	1,58E-19
0,00019	7,81E-05	4,83E-13	8,02E-19	5	1,6E-19
0,000234	0,000158	3,28E-13	9,67E-19	6	1,61E-19
0,000223	1,21E-05	9,07E-13	9,62E-19	6	1,6E-19
0,000222	0,000134	3,8E-13	9,47E-19	6	1,58E-19
0,000214	6,69E-05	6,35E-13	9,64E-19	6	1,61E-19