

Jak měřit foťákem

FYZSEM 2018

FJFI ČVUT

Šolarová Adéla

Holeksová Marie

Ing. Majer Michal

Obsah

Velikost

Teplotní roztažnost

Mechanické napětí

Rotace země

Měření velikosti velice malých, či
vzdálených objektů

Pomůcky

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foták

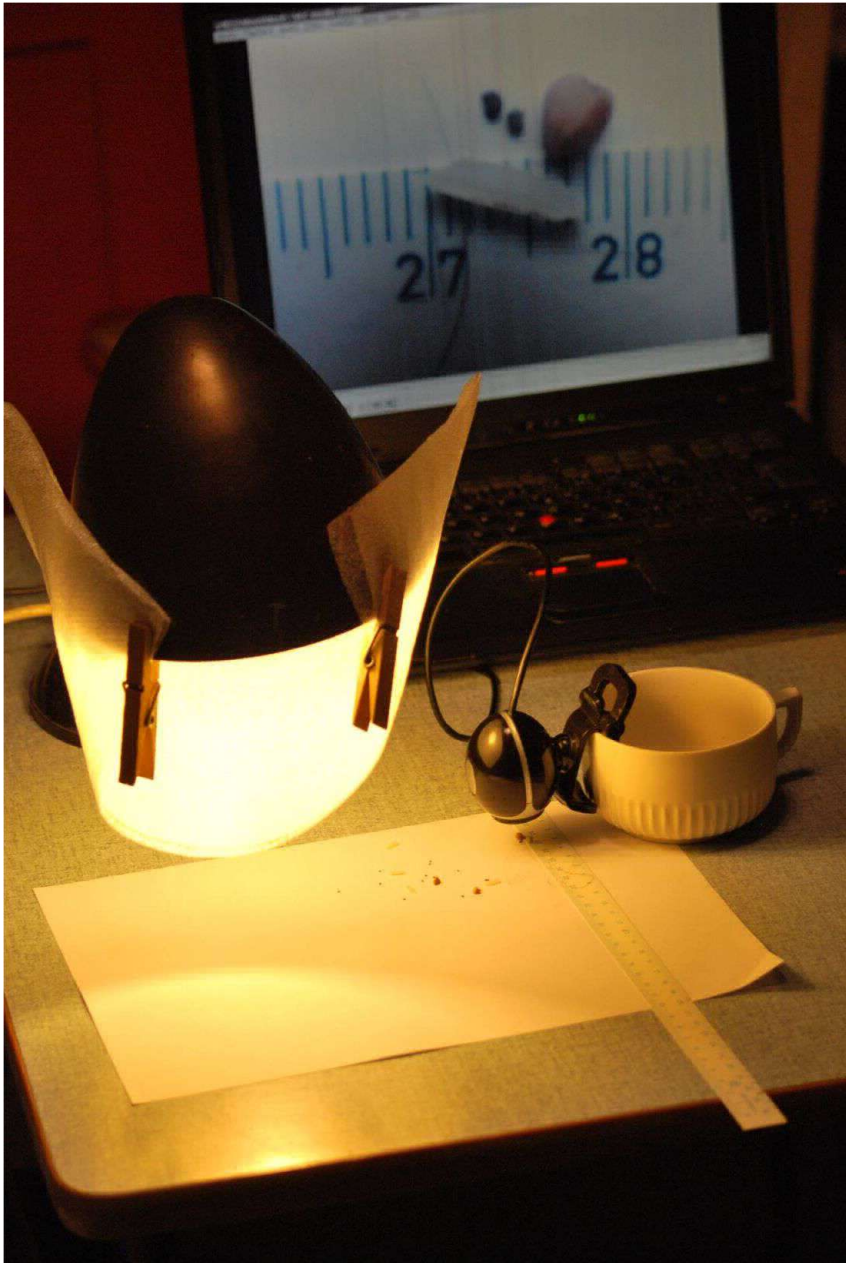
zkoumané předměty

.

(mezikroužky, webkamera, difuzér, pravítko, osvětlení, ...)

Postup

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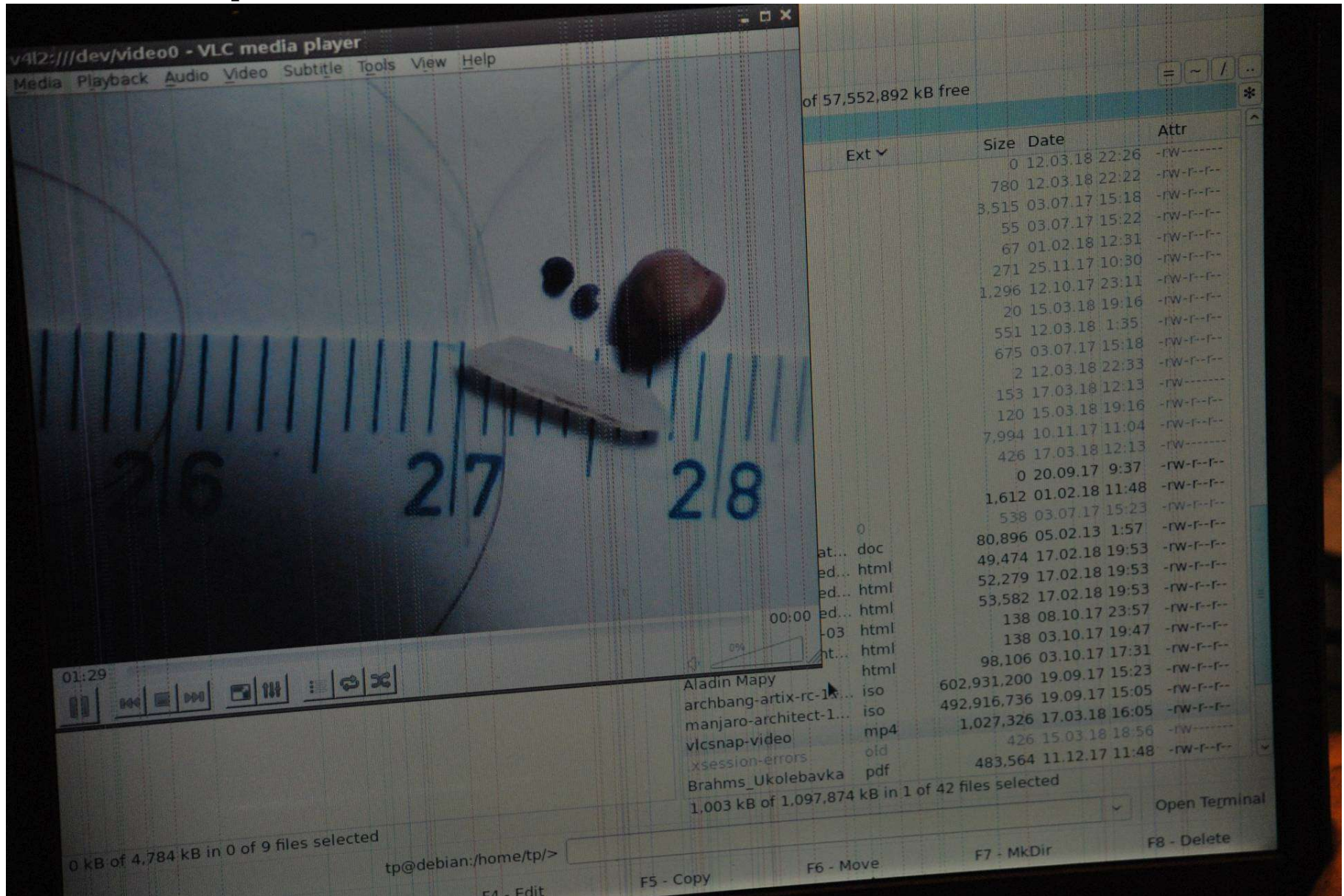
Postup

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Postup

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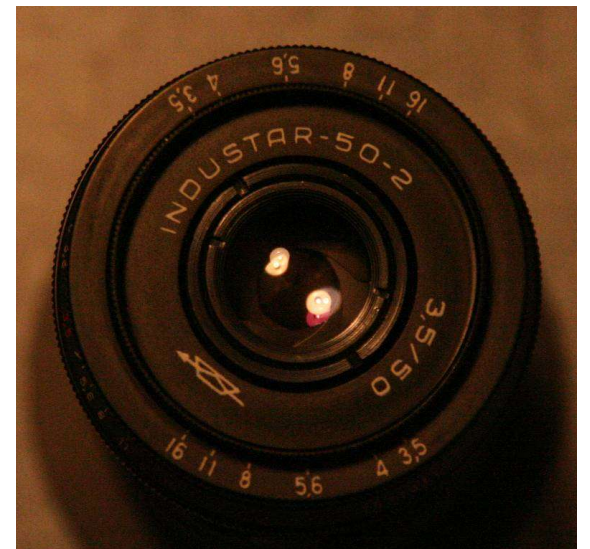
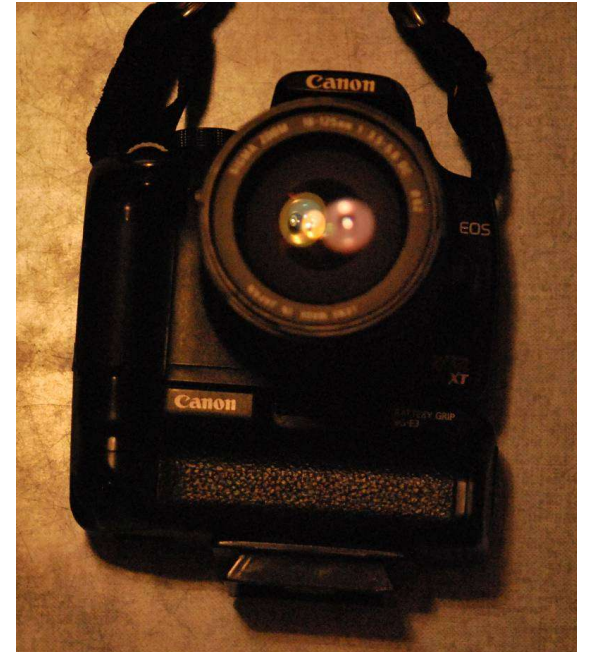
Postup

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Postup

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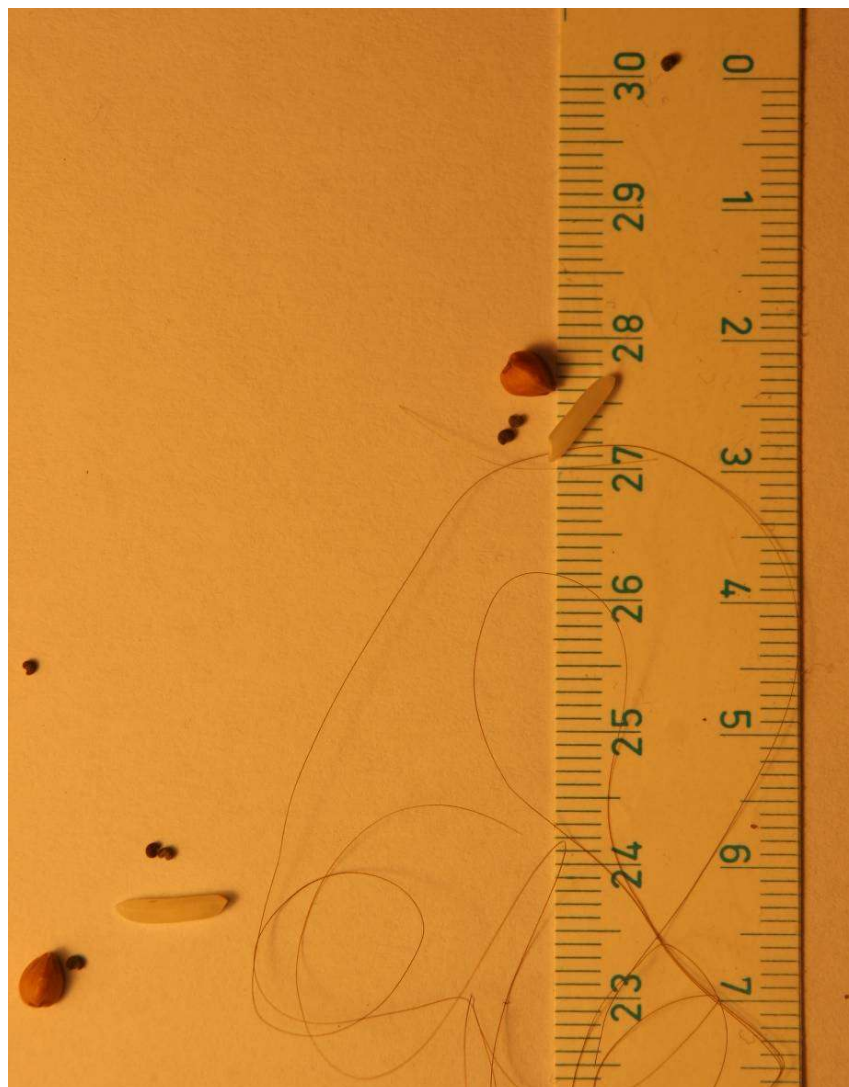
Postup

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Postup

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rýže	1266	[px]
	8.2745	[mm]
pohanka	647	[px]
	4.2288	[mm]
mák	168	[px]
	1.0980	[mm]
vlas1	10	[px]
	0.0654	[mm]
vlas2	9	[px]
	0.0588	[mm]

1 mm = 153 px



Postup

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11/16

Aladin Mapy

International Space Station Tran...

See the International Space Station in front of the Moon!

HIDE CENTER LINES

HIDE OBSERVER

CLOSE MAP [4]



« PREVIOUS

NEXT »



Sunday 2018-03-25 00:34:59.93

ISS angular size: 21.70"

Az.: 284.3°; Alt.: 13.5°

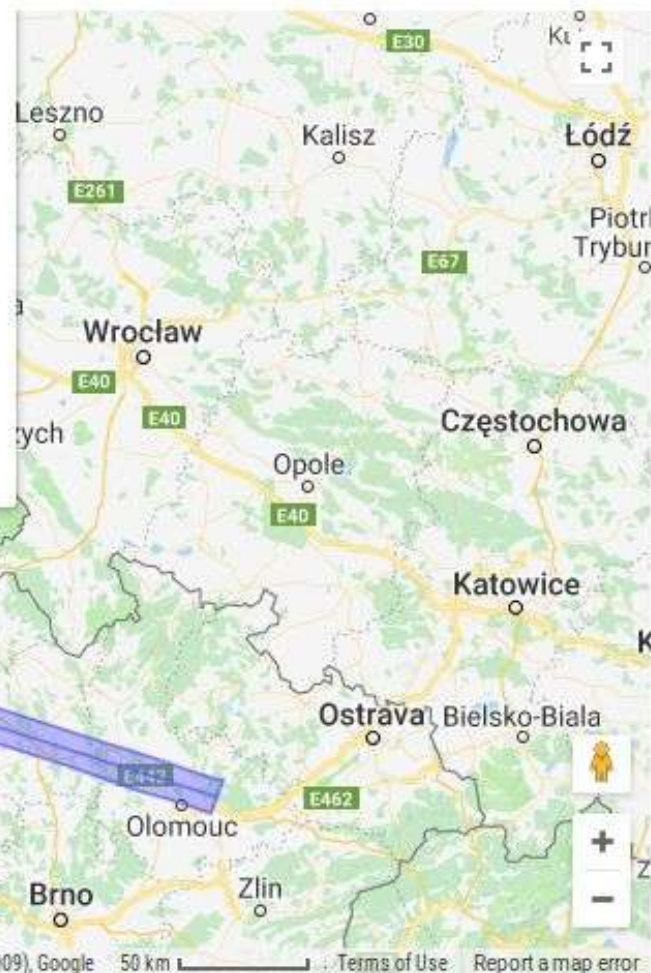
Transit duration: 3.89 s

9, 250 65 Libeznice, Czechia

$\phi = 50^{\circ} 12' 37.70'' N$; $\lambda = 14^{\circ} 29' 49.22'' E$; $h = 207 m$

Distance from current location: 3.41 km

RECALCULATE FOR THIS LOCATION



ALL TRANSITS

ONLY LUNAR

ONLY SOLAR

ONLY SELECTED

12/16

Time.is 18:41

International Space Station Tran...

HIDE CENTER LINES

HIDE OBSERVER

CLOSE MAP



ALL TRANSITS

ONLY LUNAR

ONLY SOLAR

ONLY SELECTED

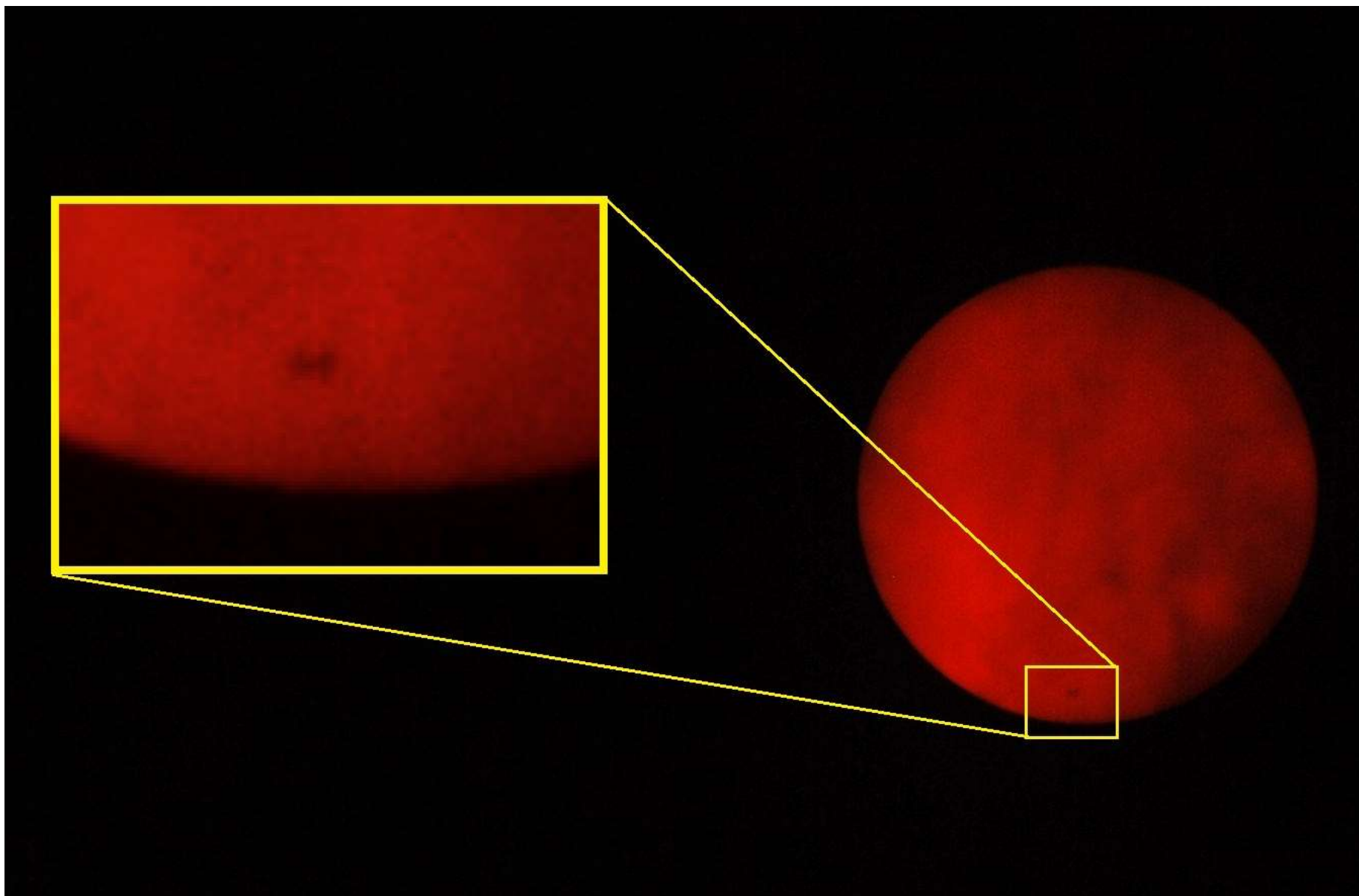
Postup

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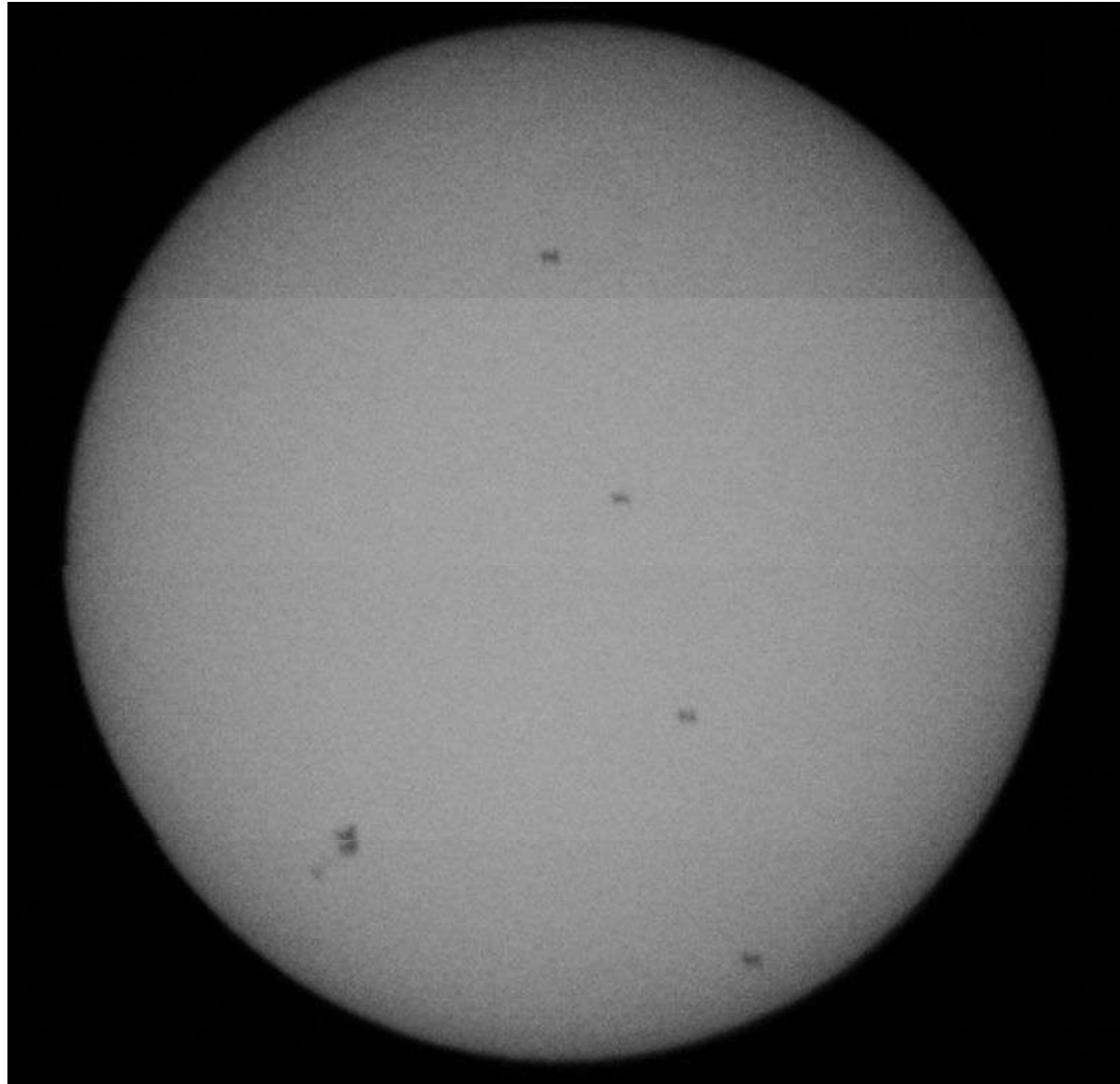
Postup

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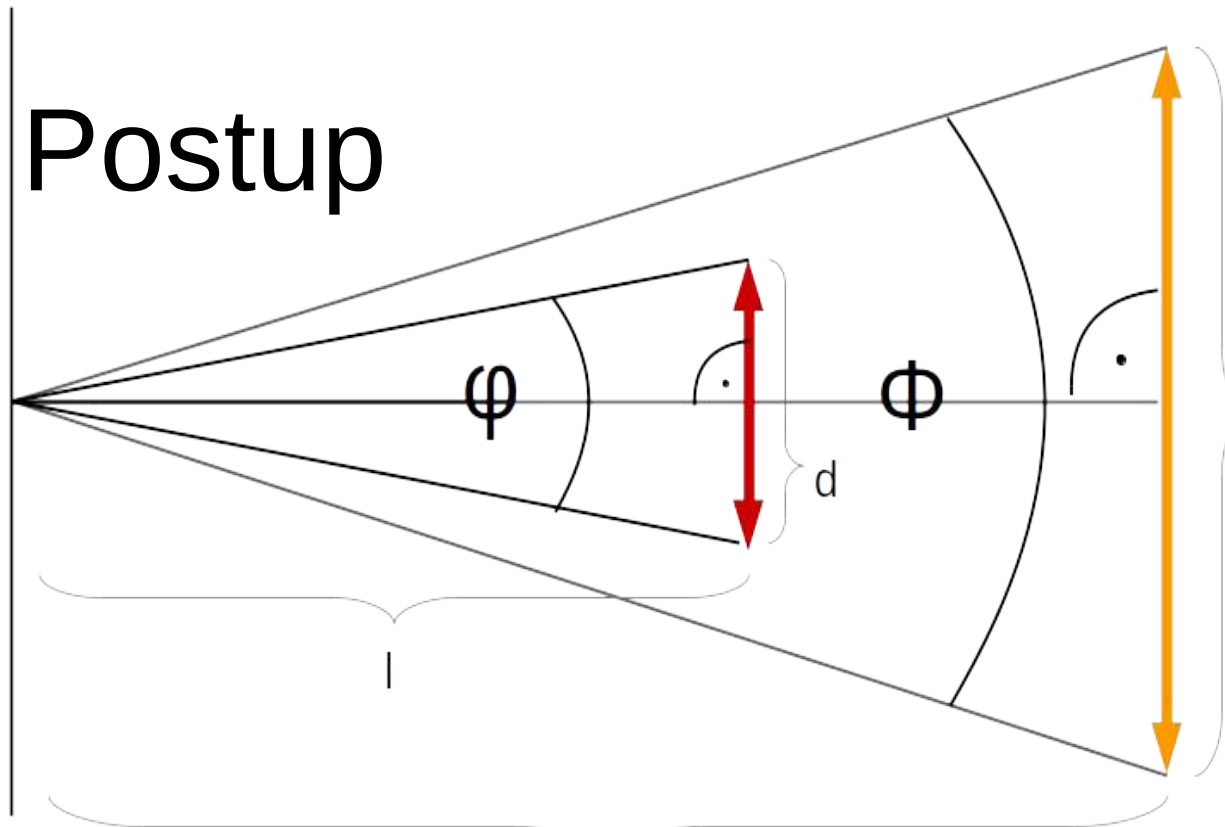


Postup

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Postup



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Průměr S

$D = 1\,392\,020$ km

Vzdálenost S – Z

$L = 149,6 \cdot 10^6$ km

$$\operatorname{tg}\left(\frac{\Phi}{2}\right) = \frac{D}{2L}$$

$$\Phi = 2 \operatorname{arctg}\left(\frac{D}{2L}\right)$$

$$\Phi = 32'$$

$$\begin{array}{l} L \quad 32' \dots\dots 455 \text{ px} \\ \varphi \quad \dots\dots 10 \text{ px} \\ \hline \varphi = 0.7' = 42.2'' \end{array}$$

chyba odečtu ± 2 px
max chyba $\varphi \pm 8,7''$

$$\operatorname{tg}\left(\frac{\varphi}{2}\right) = \frac{d}{2l}$$

$$l = \frac{d}{2 \operatorname{tg}\left(\frac{\varphi}{2}\right)}$$

$$l = (533 \pm 92) \text{ [km]}$$

($l = 536$ km)

Obsah

Velikost

Teplotní roztažnost

Mechanické napětí

Rotace země

Součinitel teplotní závislosti odporu
a teplotní roztažnosti

Pomůcky

1/20

foták, stativ

laser, úchyt laseru s pákou, neznámý drát, svorky

měřidla: metr, stopky, voltmetr, ampérmetr, ohmmetr

řiditelný zdroj

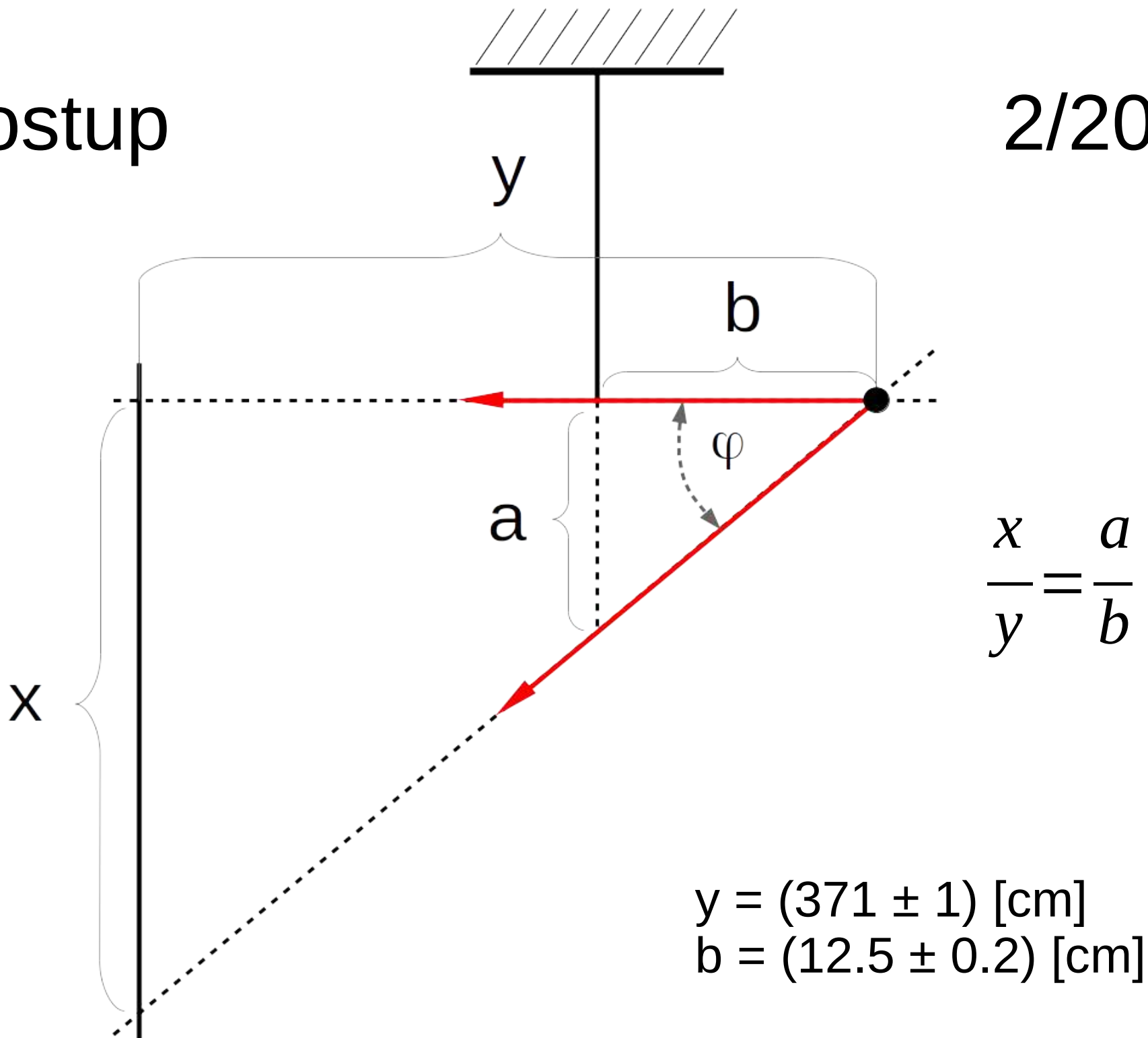
propojovací kabely

teploměr, rychlovarná konvice, voda

(reostat, páječka, ...)

Postup

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Délková tep. roztažnost

$$l = l_0 (1 + \alpha_l \Delta \vartheta)$$

l_0 délka drátu

$$l_0 = 97,7 \text{ [cm]}$$

Tep. závislost odporu

$$R_v = R_p (1 + \alpha_R (\vartheta_v - \vartheta_p))$$

ϑ_p teplota vody před zahřátím

ϑ_v teplota vody ohřívané v konvici

R_p odpor drátu před zahřátím

R_v odpor při rostoucí ϑ_v

Postup

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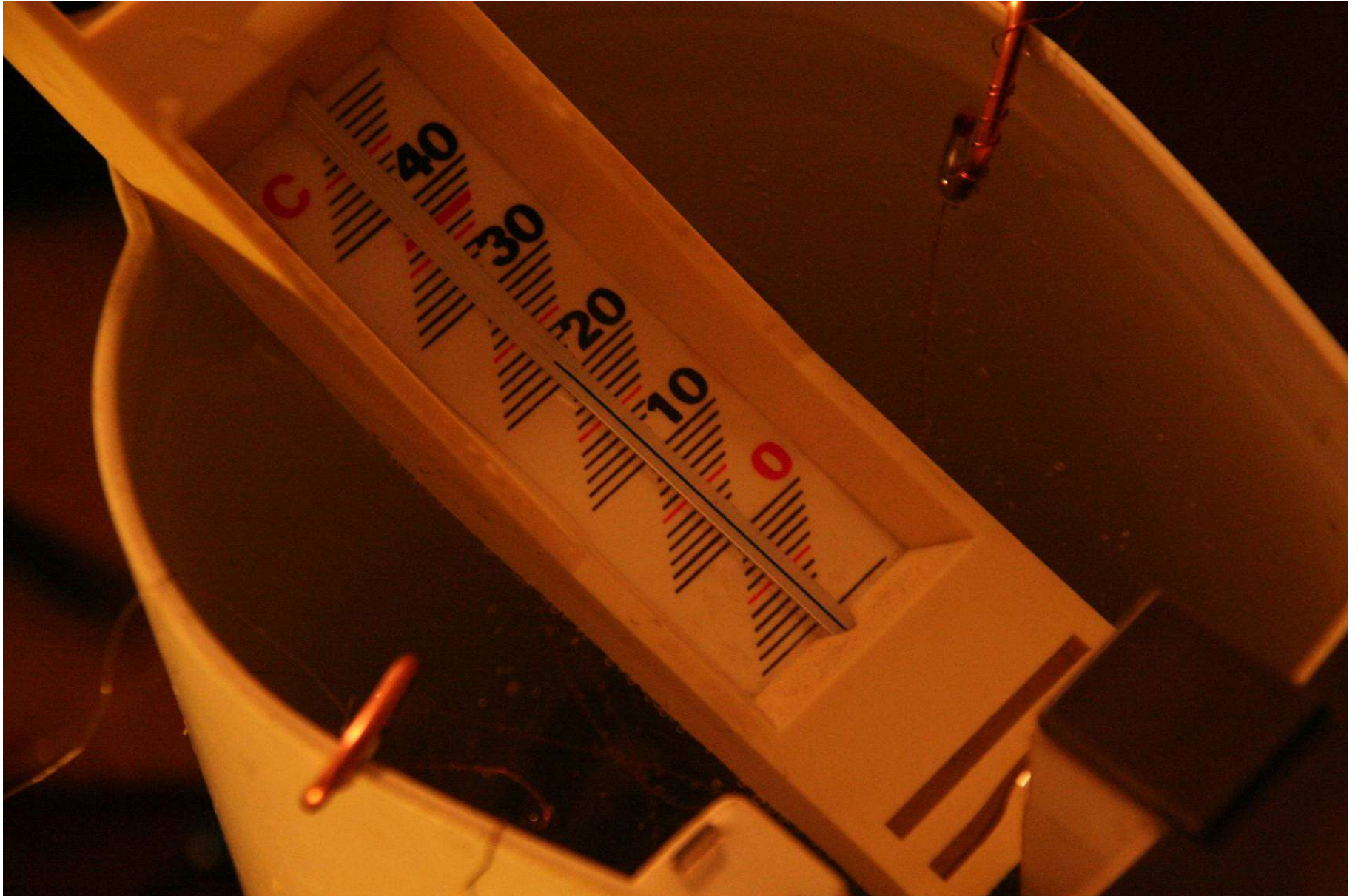
Postup

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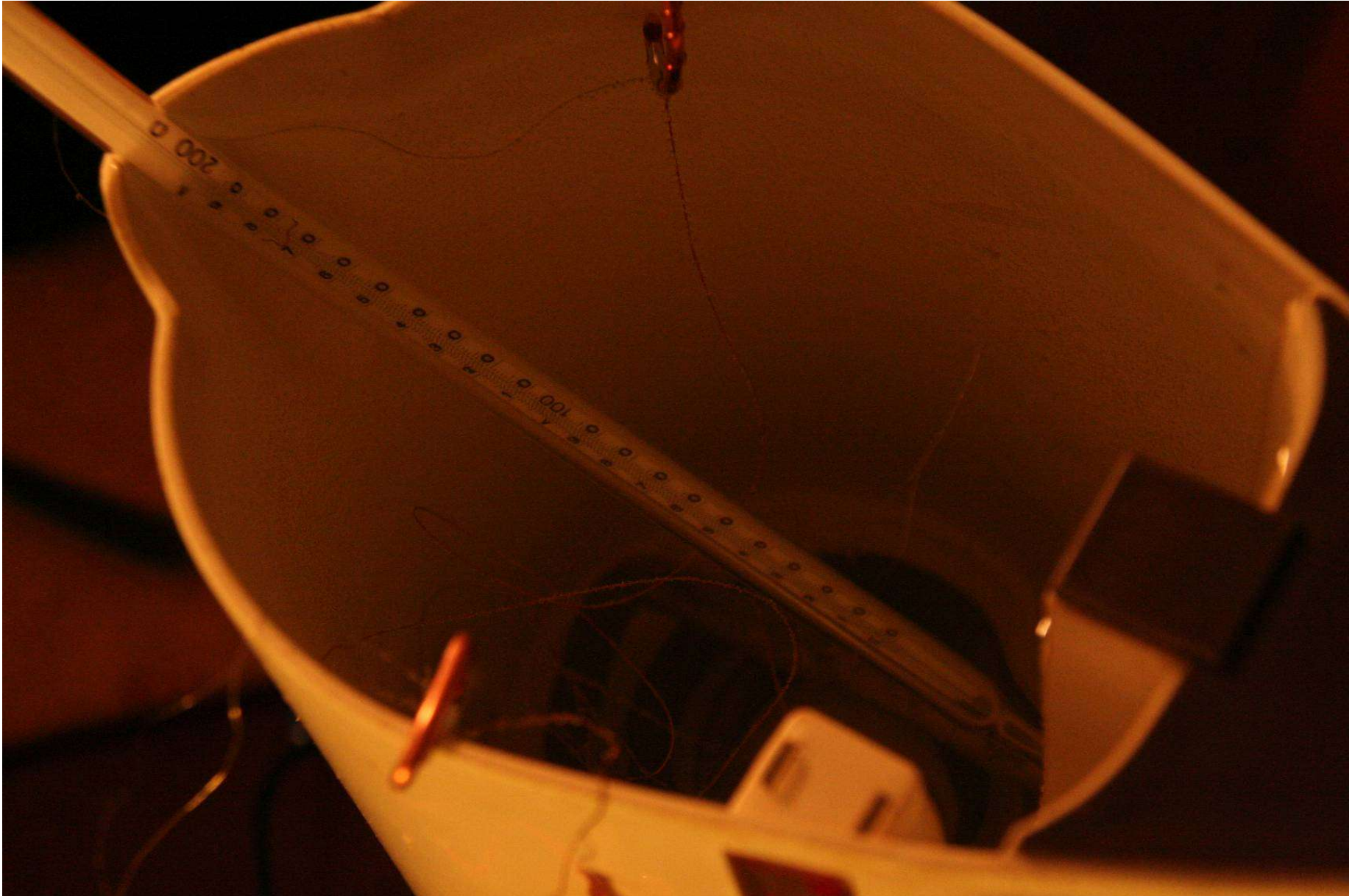
Postup

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Postup

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Postup

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$$\vartheta_p = (14 \pm 1) [^{\circ}\text{C}]$$

$$R_p = (425 \pm 0,6) [\text{m}\Omega]$$

$$R_v = R_p \left(1 + \alpha_R (\vartheta_v - \vartheta_p) \right)$$

$$\alpha_R = \frac{R_v - R_p}{R_p (\vartheta_v - \vartheta_p)}$$

ϑ_v [$^{\circ}\text{C}$]	R_v^* [$\text{m}\Omega$]	α_R [$1/^{\circ}\text{C}$]
43	473	0.003895
49	483	0.003899
62	507	0.004020
71	521	0.003963
80	536	0.003957
89	550	0.003922
99	568	0.003958

Součinitel tep. závislosti odporu

$$\alpha_R = (0.0039 \pm 0.0001) [\text{K}^{-1}]$$

tab. hodnota: $\alpha_R = 0.004 [\text{K}^{-1}]$

*chyba $R_v \pm (0.02\% \text{ MH} + 0.005\% \text{ MHMR})$

Postup

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Délková tep. roztažnost

$$l = l_0 (1 + \alpha_l \Delta \vartheta)$$

Ohmův zákon

I proud procházející drátem

U napětí na drátu

R odpor drátu

$$R = \frac{U}{I}$$

Tep. závislost odporu $R_2 = R_1 (1 + \alpha_R (\vartheta_2 - \vartheta_1))$

ϑ_1, ϑ_2 teplota drátu před a po zahřátí proudem

R_1, R_2 odpor drátu před a po zahřátí

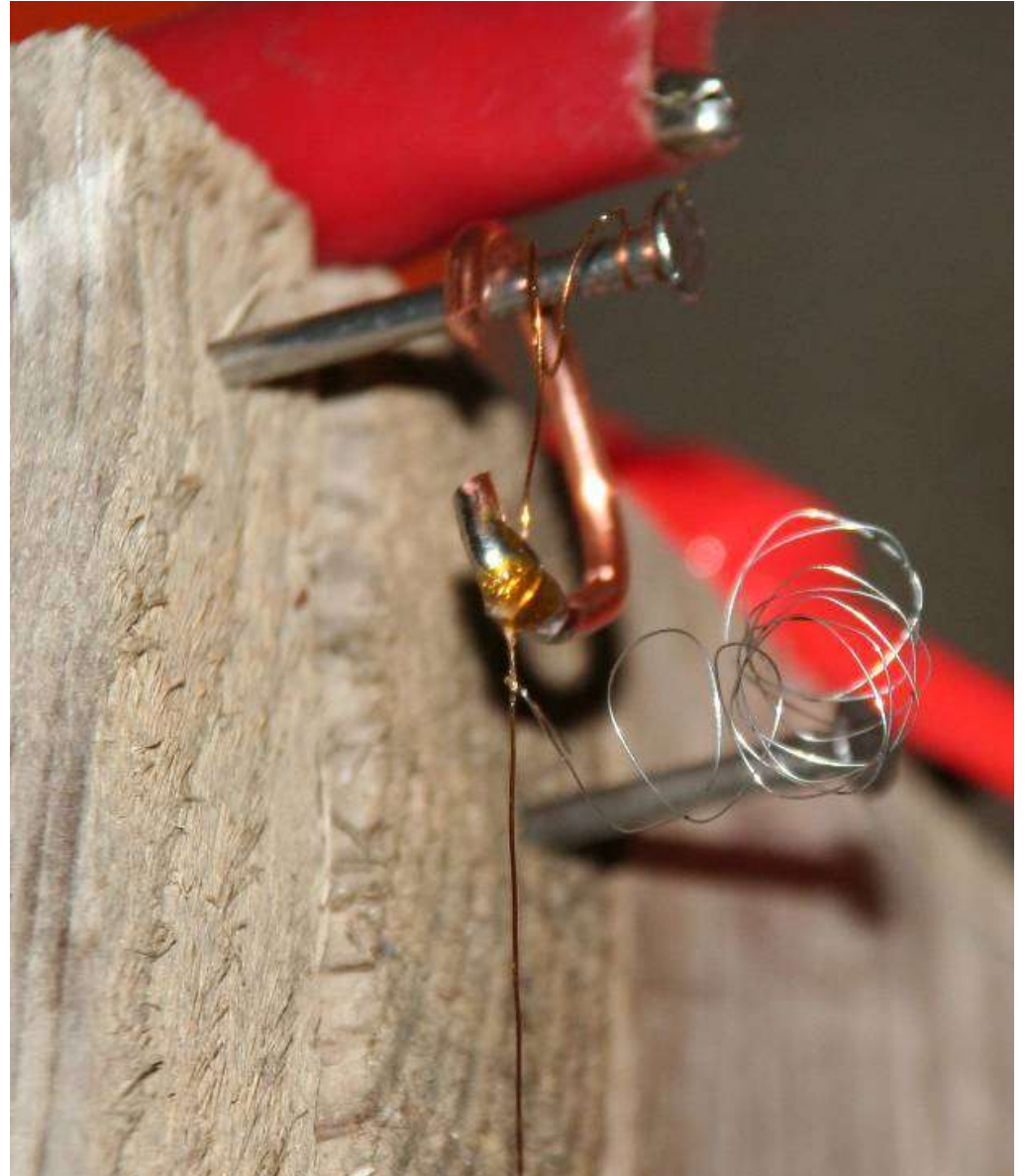
Postup

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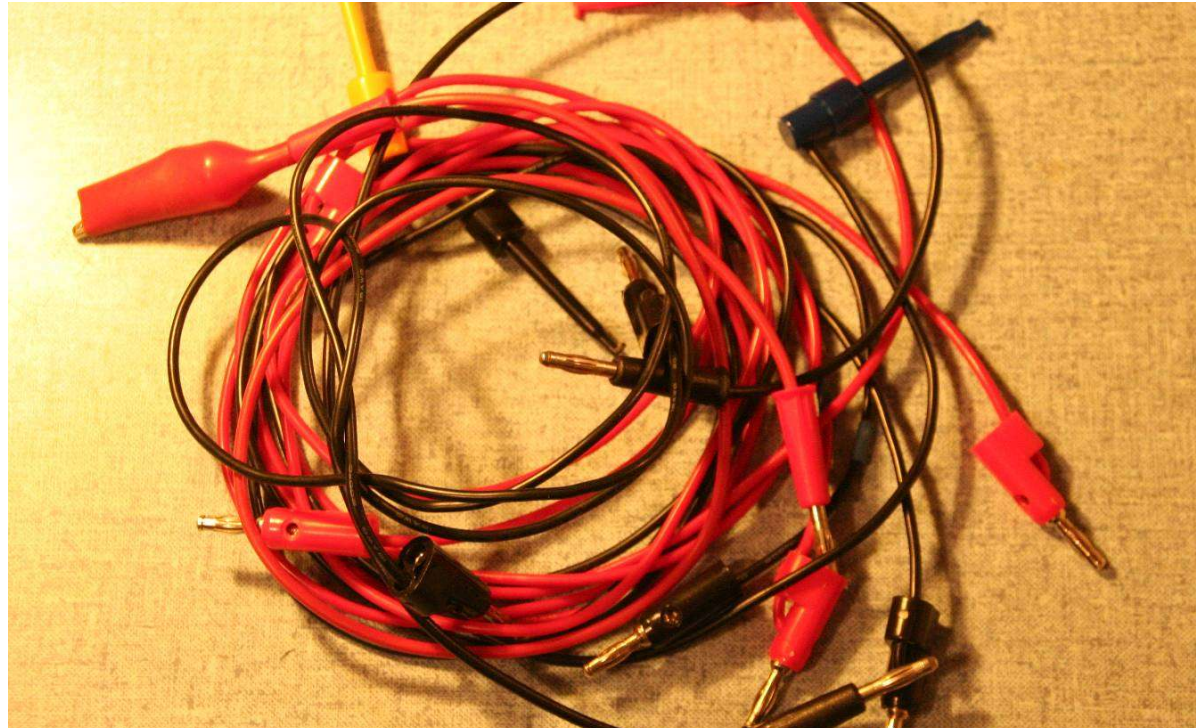
Postup

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Postup

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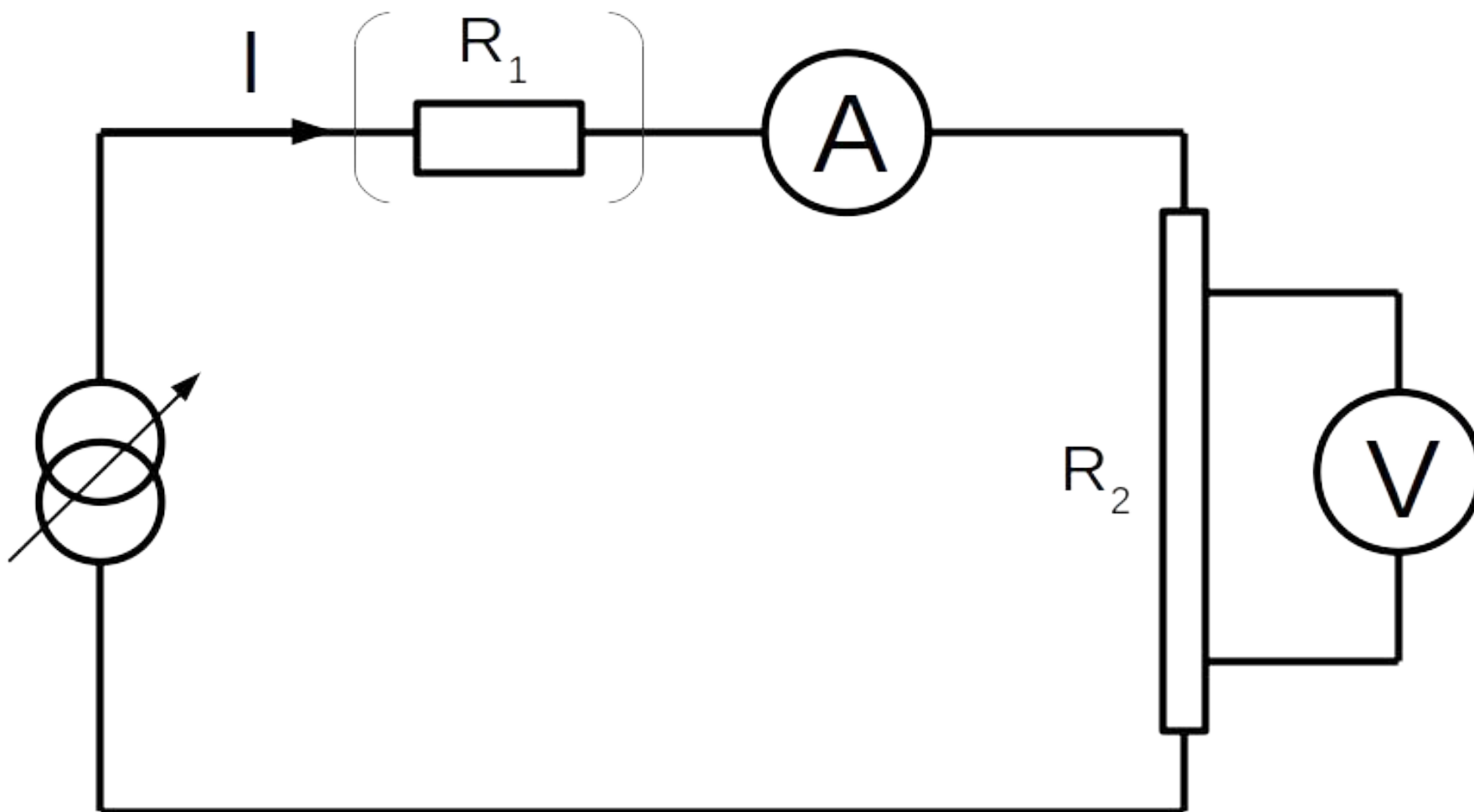
Postup

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I*	U prumer*	R1	ϑ1
[A]	[mV]	[mΩ]	[°C]
0.0	0.053	/	/
0.1	42.44	423.9	17.0

I*	U prumer*	R2	ϑ2
[A]	[mV]	[mΩ]	[°C]
0.5	214.8	429.5	20.4
1.0	440.4	440.4	26.9
1.5	690.6	460.4	38.8
2.0	972.2	486.0	54.2
2.5	1,300.6	520.2	74.6
3.0	1,689.1	563.0	100.2
3.5	2,160.0	617.1	132.6

$$R = \frac{U}{I}$$

$$R_2 = R_1 (1 + \alpha_R (\vartheta_2 - \vartheta_1))$$

$$\vartheta_2 = \frac{R_2 - R_1}{R_1 \alpha_R} + \vartheta_1$$

*chyba I ± (0.001 * MHMR + 0.5% MHMR)

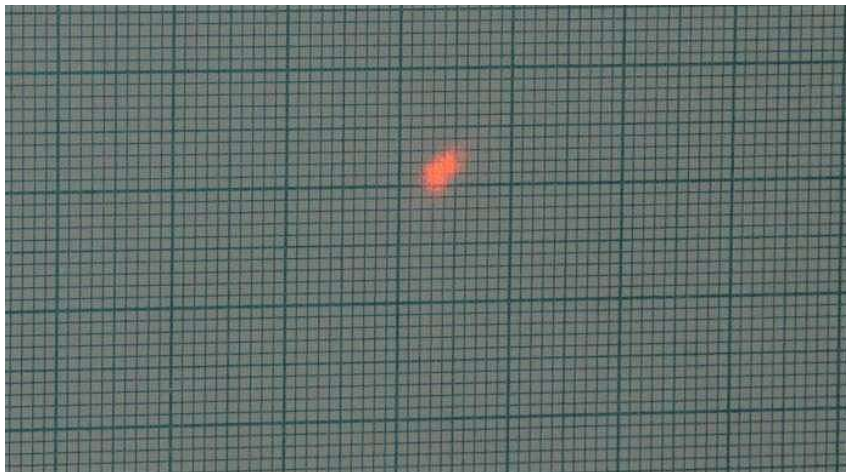
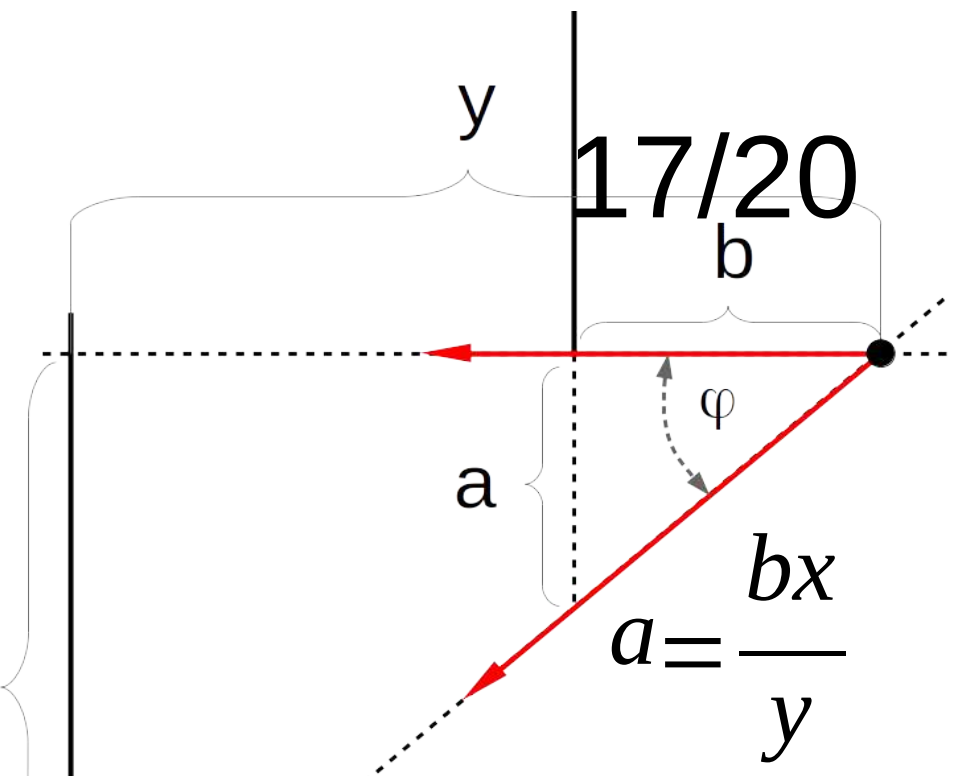
chyba U ± (0.01% MH + 0.01% MHMR)

Postup

$$l = l_0 (1 + \alpha_l \Delta \vartheta)$$

$$l_0 + a = l_0 (1 + \alpha_l (\vartheta_2 - \vartheta_1))$$

x

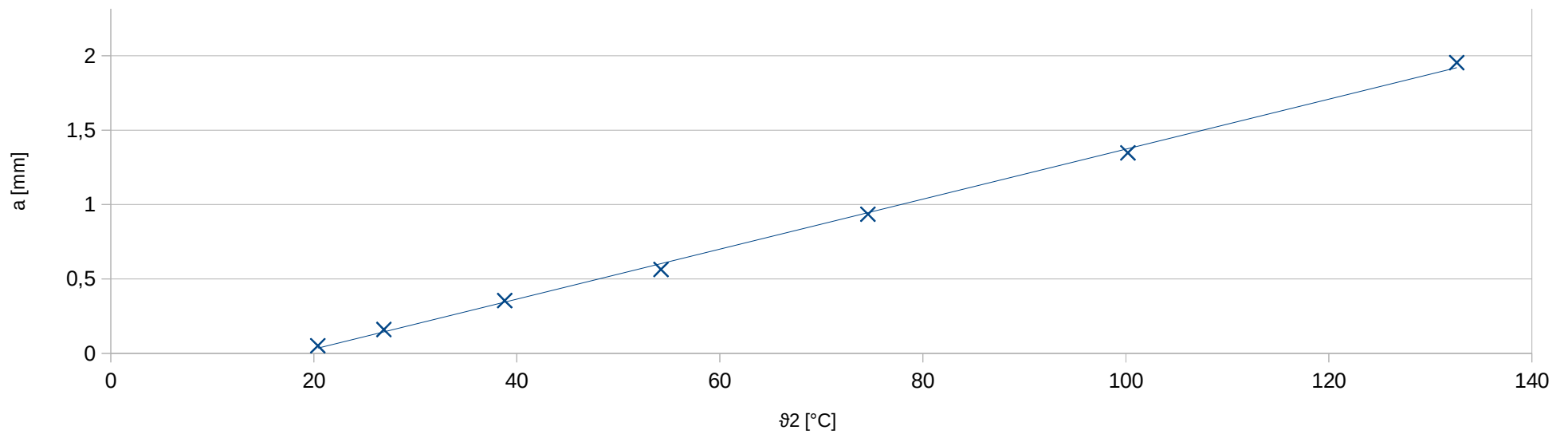
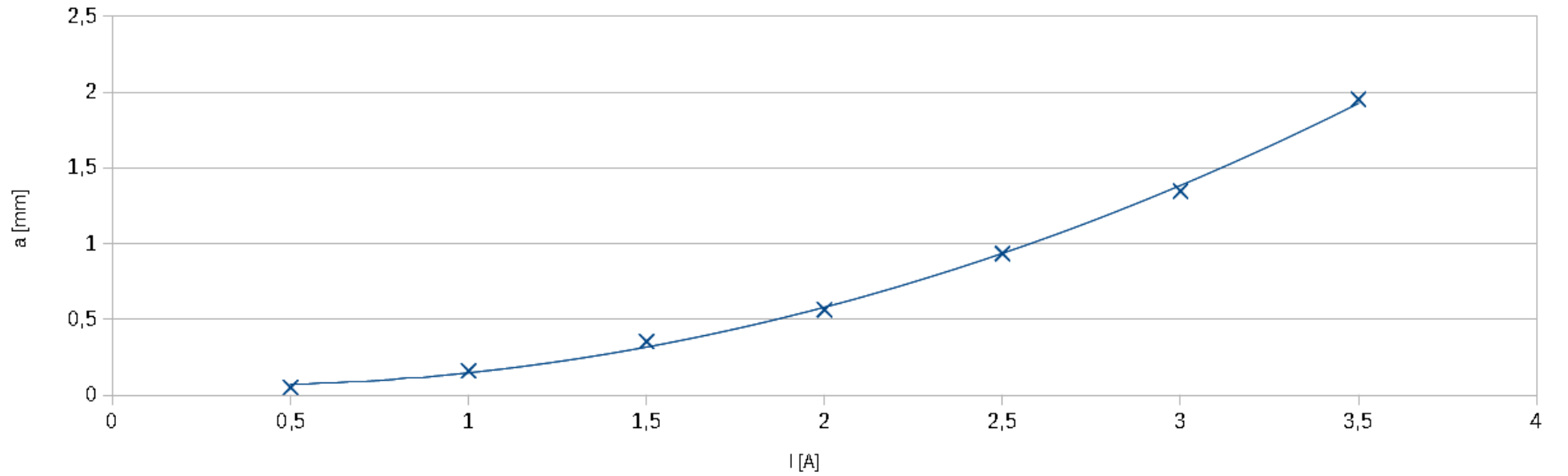


*chyba x pap $\pm 0,5$ mm
chyba x pix $\pm 0,5$ mm

l	x pap*	a pap	x pix*	a pix
[A]	[mm]	[mm]	[mm]	[mm]
0.5	1.5	0.051	1.6	0.055
1.0	4.8	0.160	5.1	0.172
1.5	10.5	0.354	10.5	0.353
2.0	16.8	0.564	17.0	0.573
2.5	27.8	0.935	27.8	0.937
3.0	40.0	1.348	40.2	1.354
3.5	58.0	1.954	57.8	1.947

Postup

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$$l_0 + a = l_0 (1 + \alpha_l (\vartheta_2 - \vartheta_1))$$

$$\alpha_l = \frac{a}{l_0 (\vartheta_2 - \vartheta_1)}$$

Papír: $\alpha_l = 0.0164 \pm 0.0026 [10^{-3}\text{K}^{-1}]$

Pixely: $\alpha_l = 0.0168 \pm 0.0011 [10^{-3}\text{K}^{-1}]$

tab. hodnota: $\alpha_l = 0.017 [10^{-3}\text{K}^{-1}]$

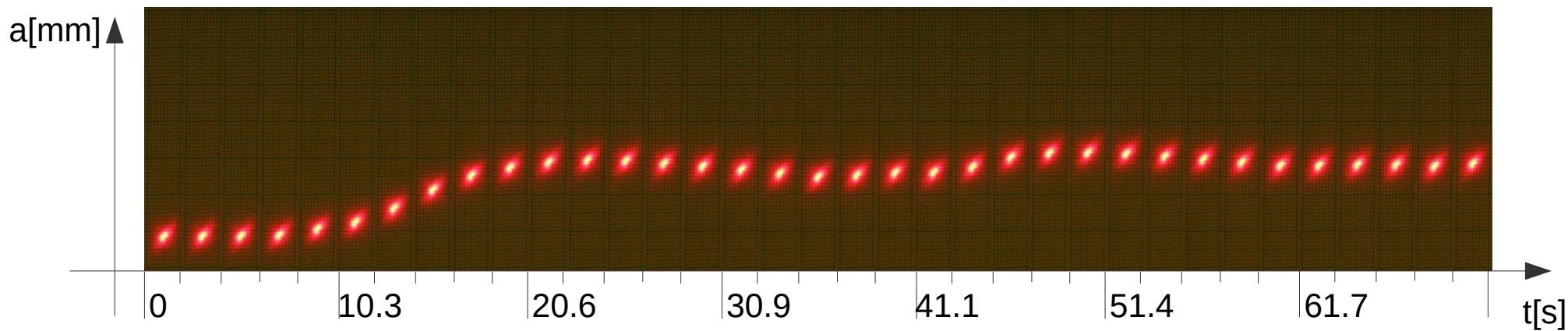
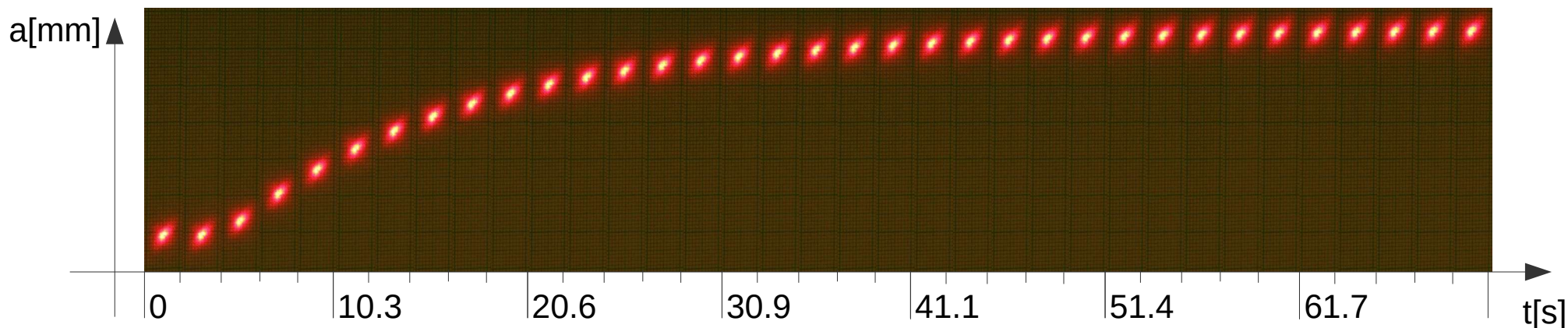
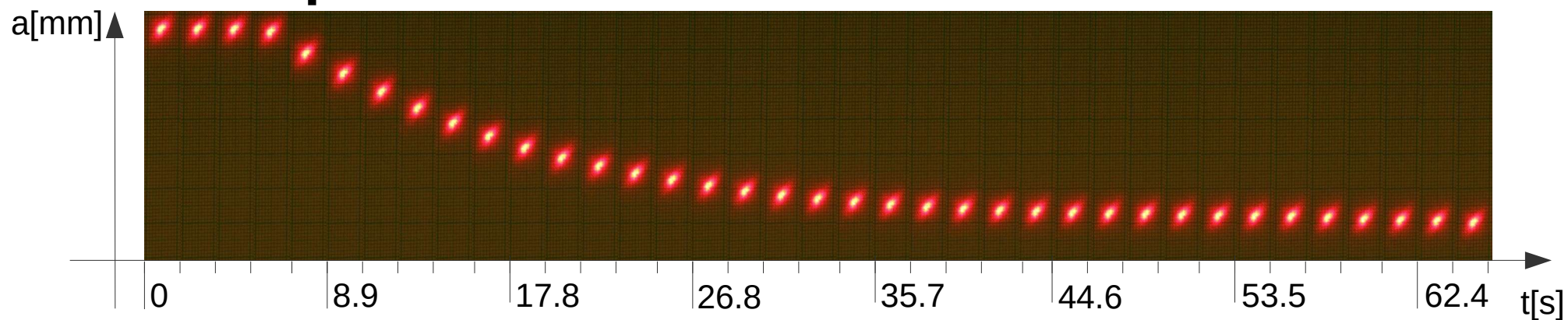
Postup

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Postup

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Obsah

Velikost

Teplotní roztažnost

Mechanické napětí

Rotace země

Mechanické napětí

Pomůcky

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foták

zdroj polarizovaného světla (notebook)

zkoumané předměty

polarizační filtr (display, rovné sklo)

Postup

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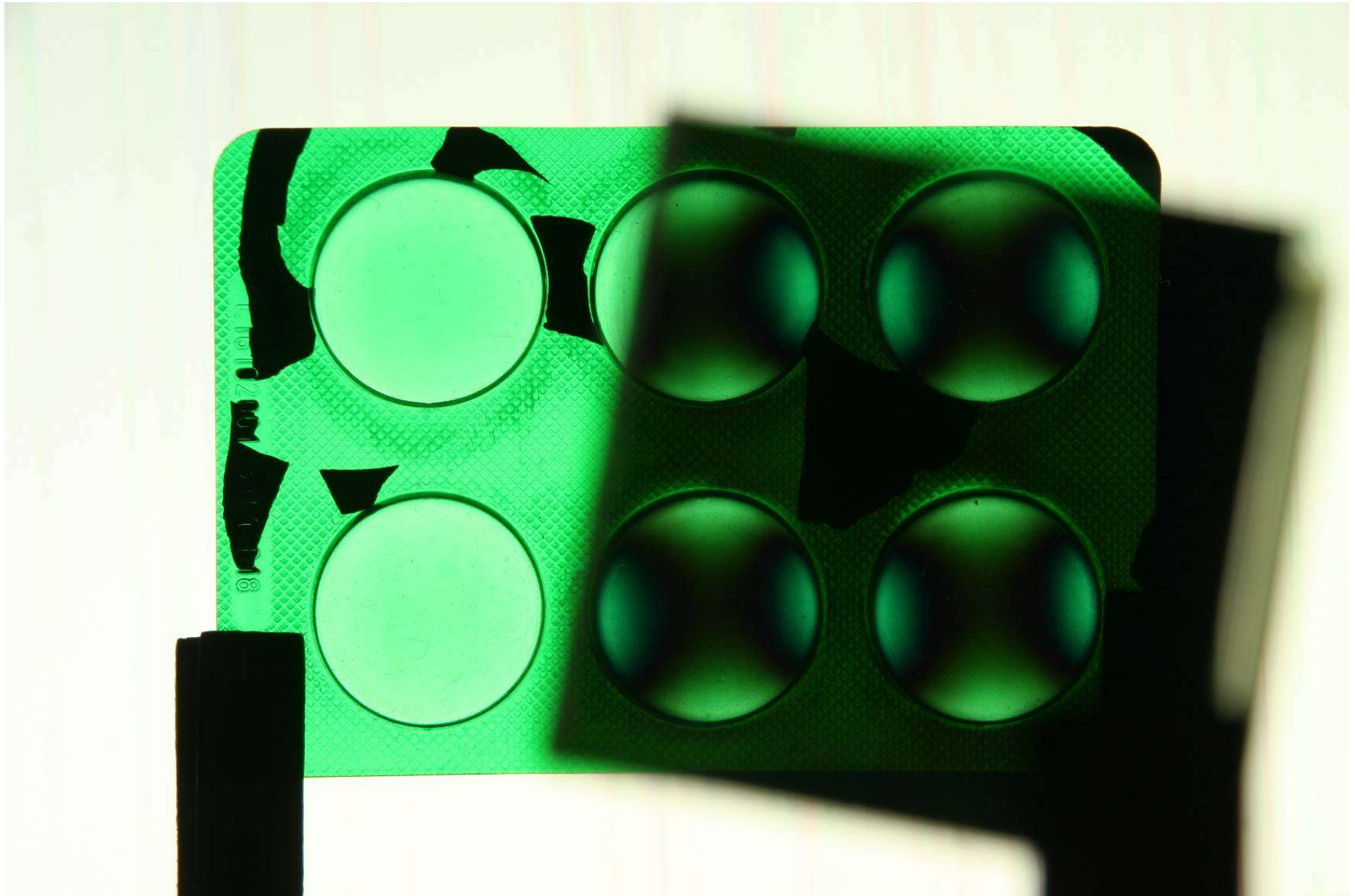
Postup

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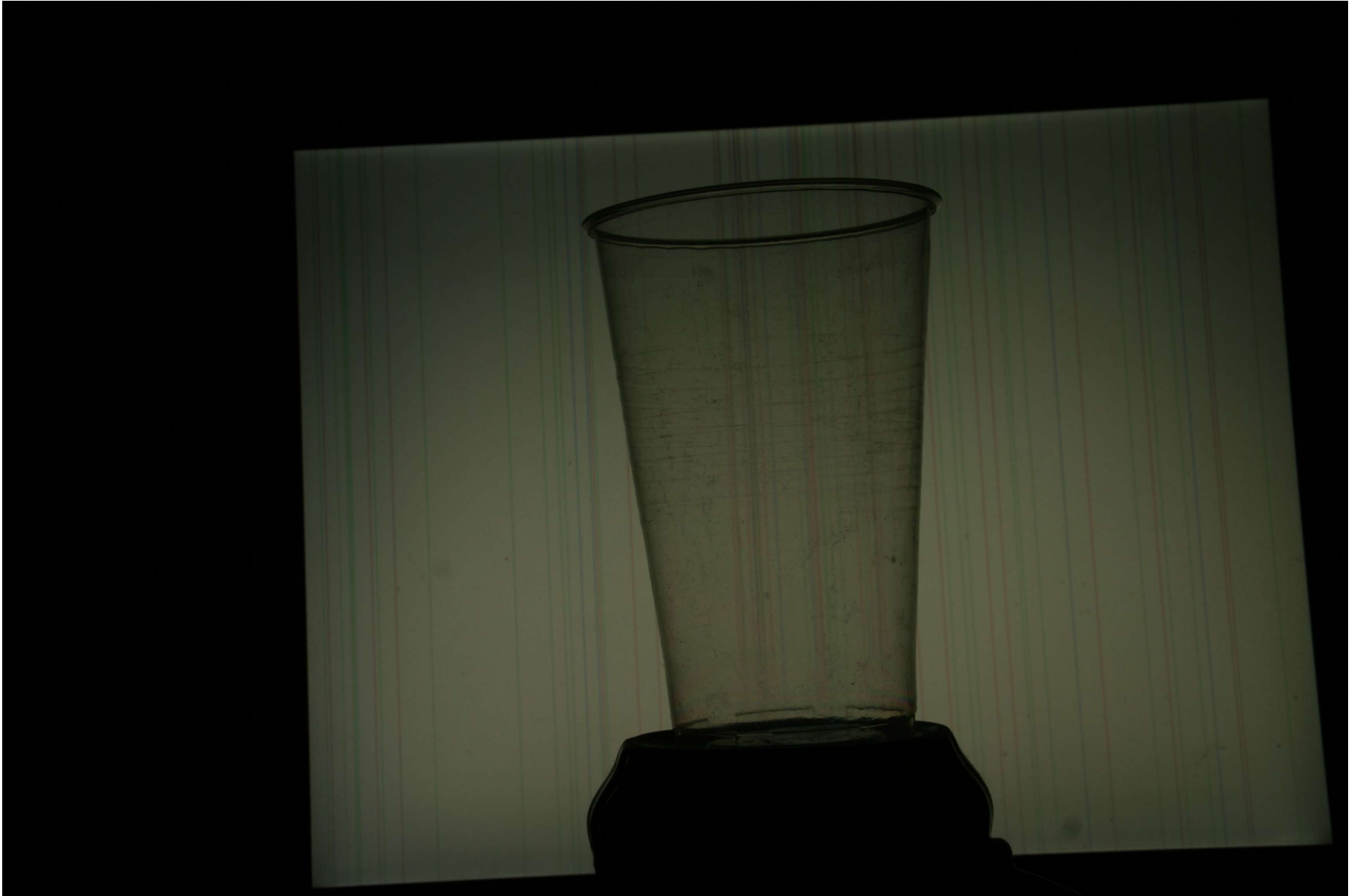
Postup

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Postup

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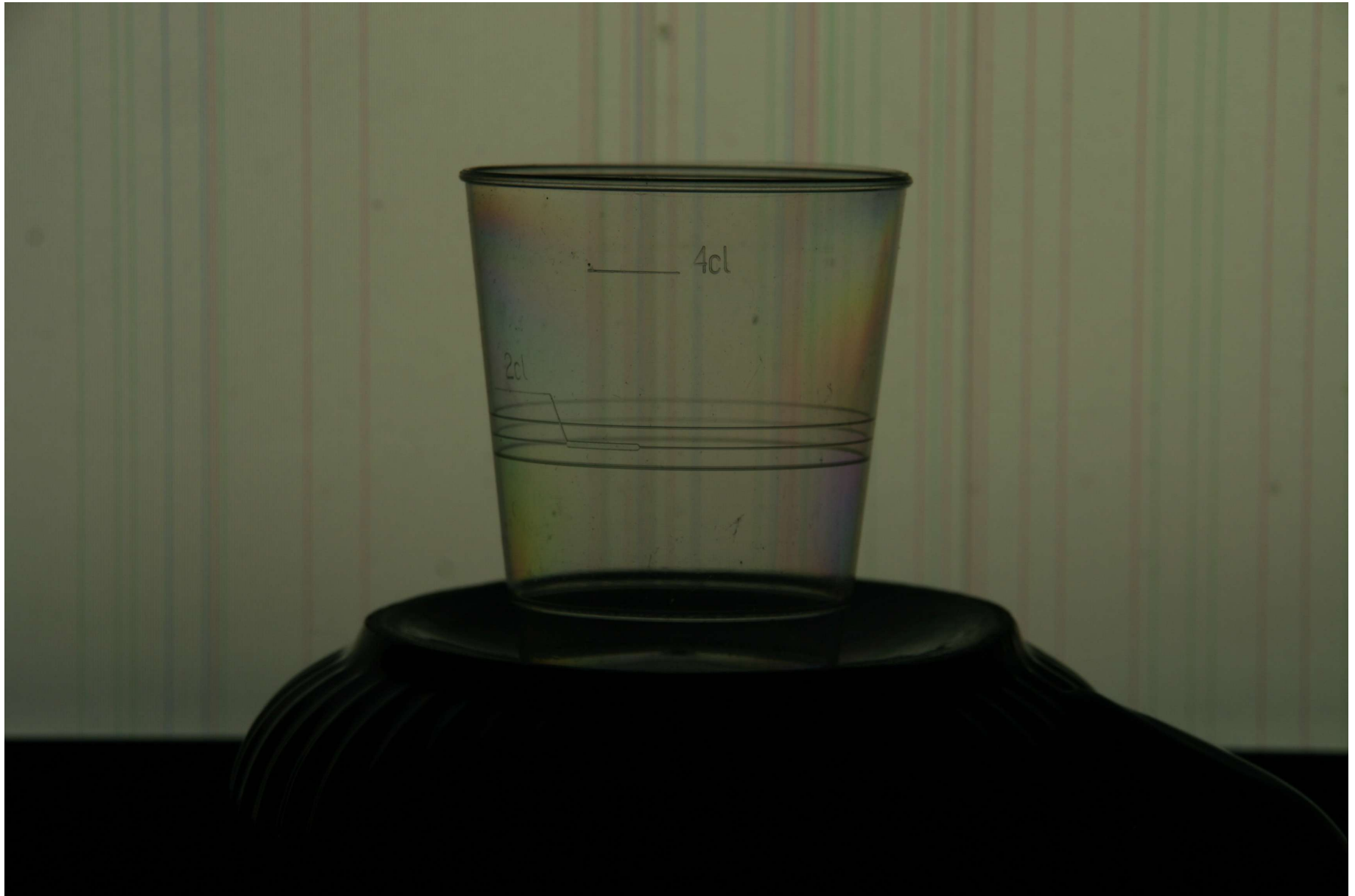
Postup

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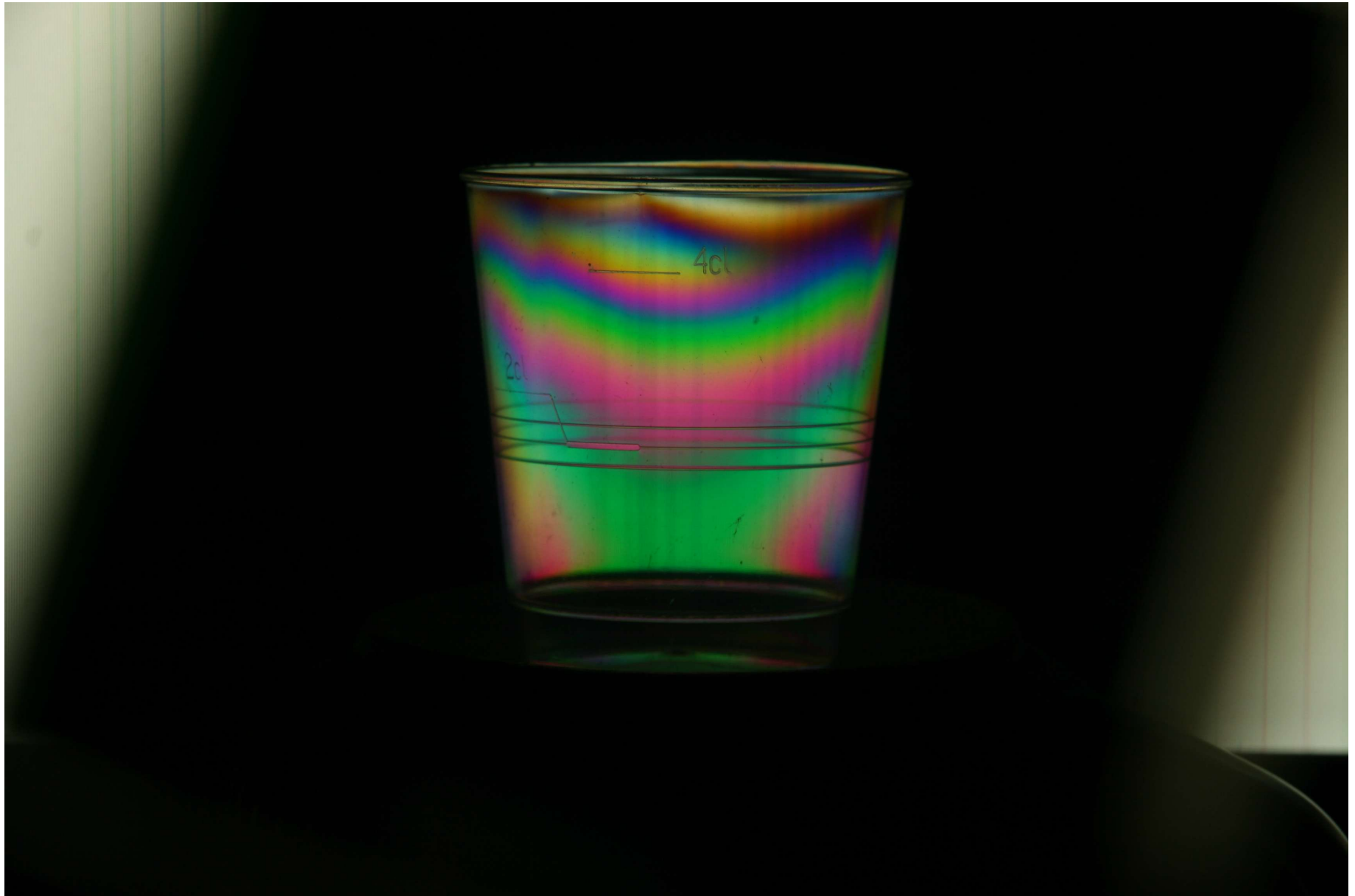
Postup

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Postup

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Postup

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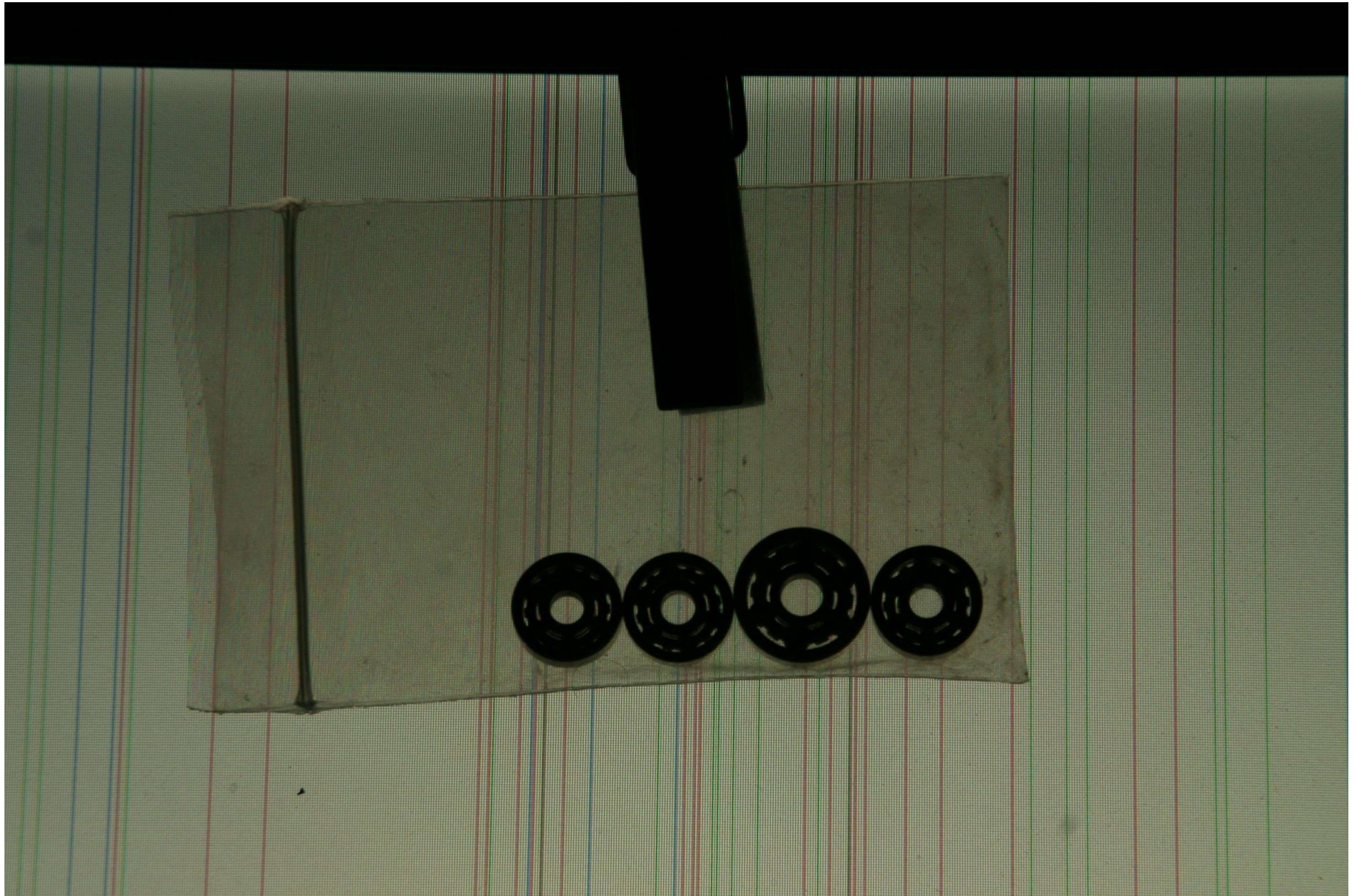
Postup

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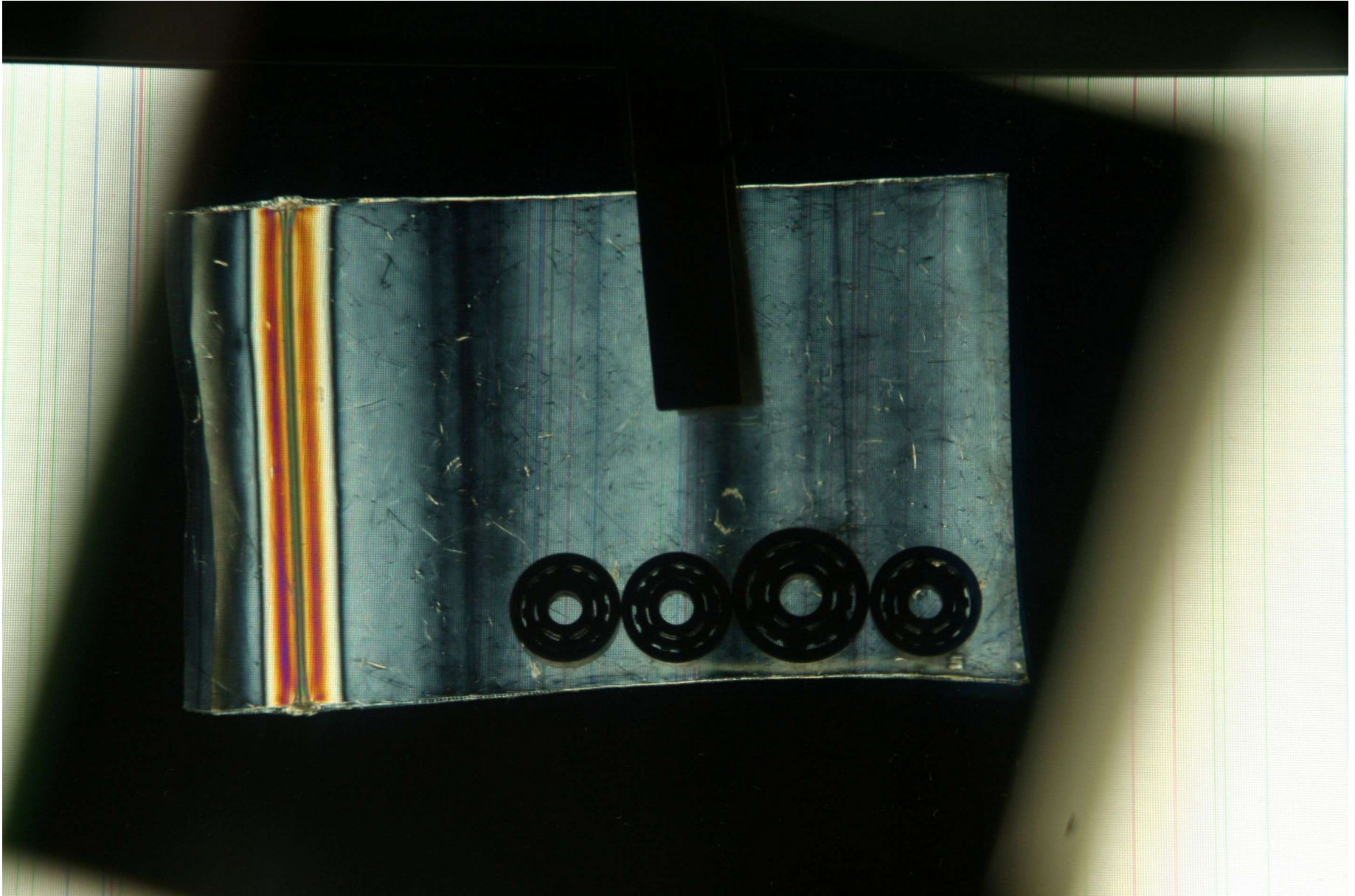
Postup

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Postup

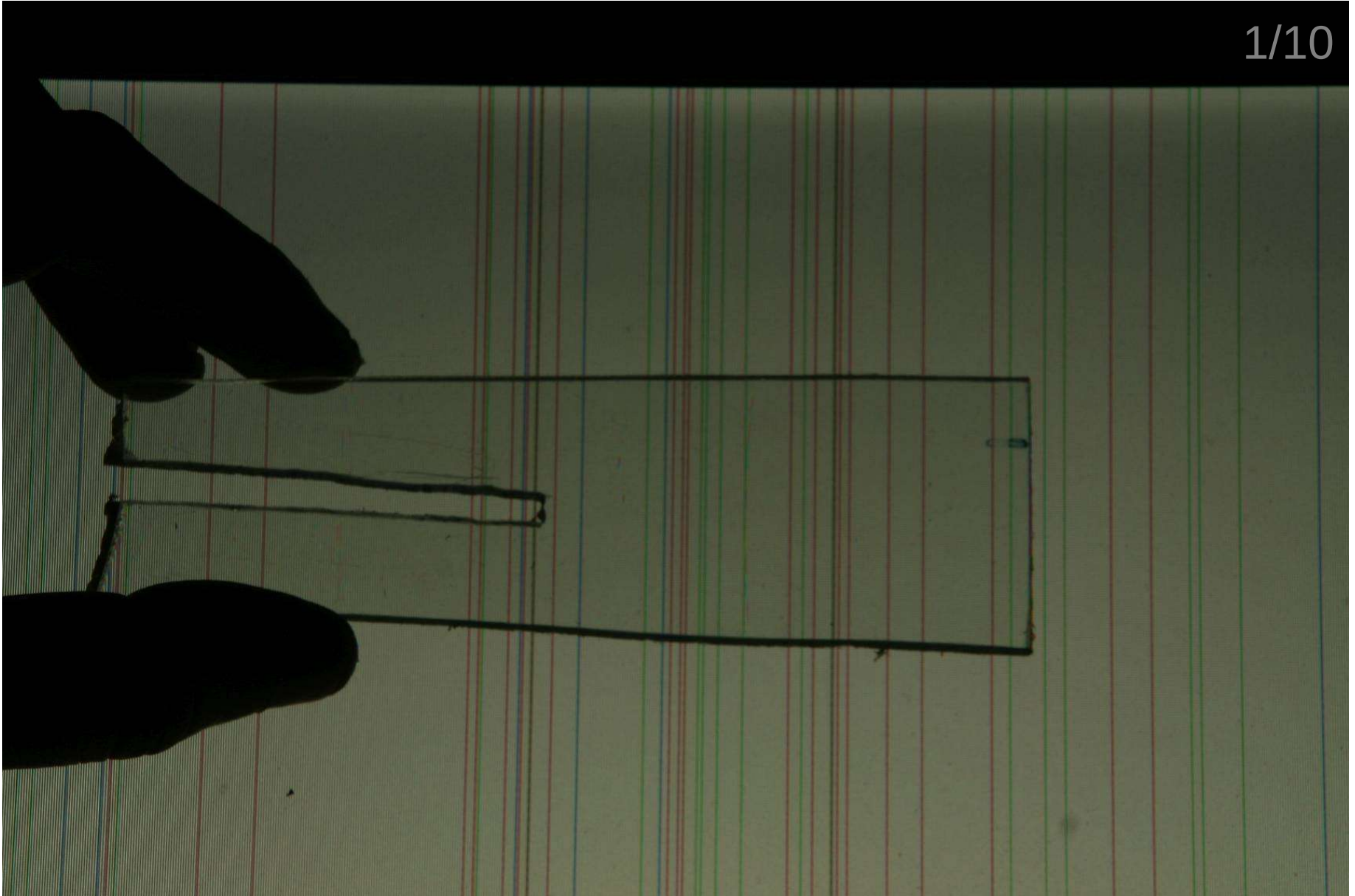
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Postup

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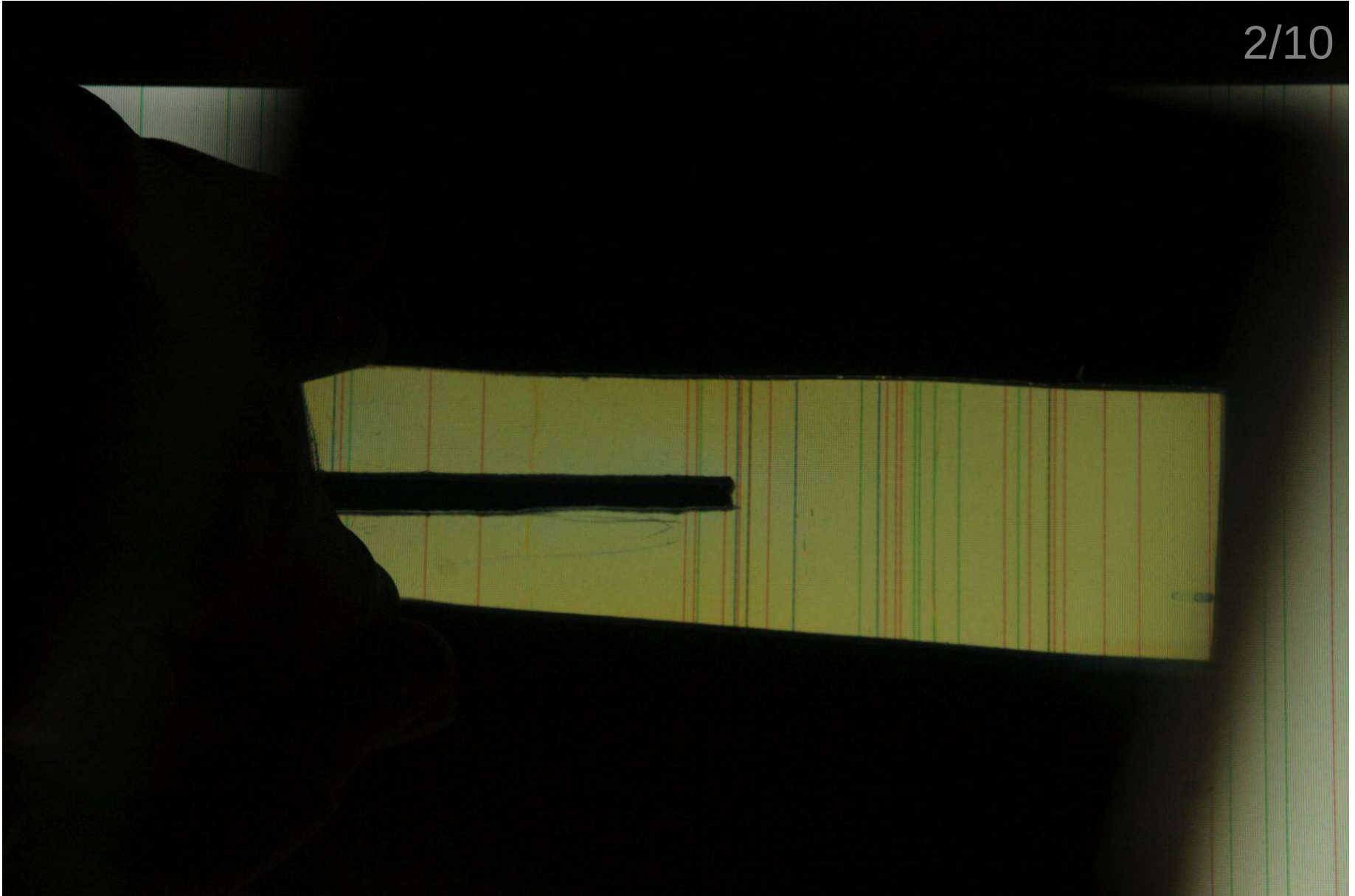
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Postup

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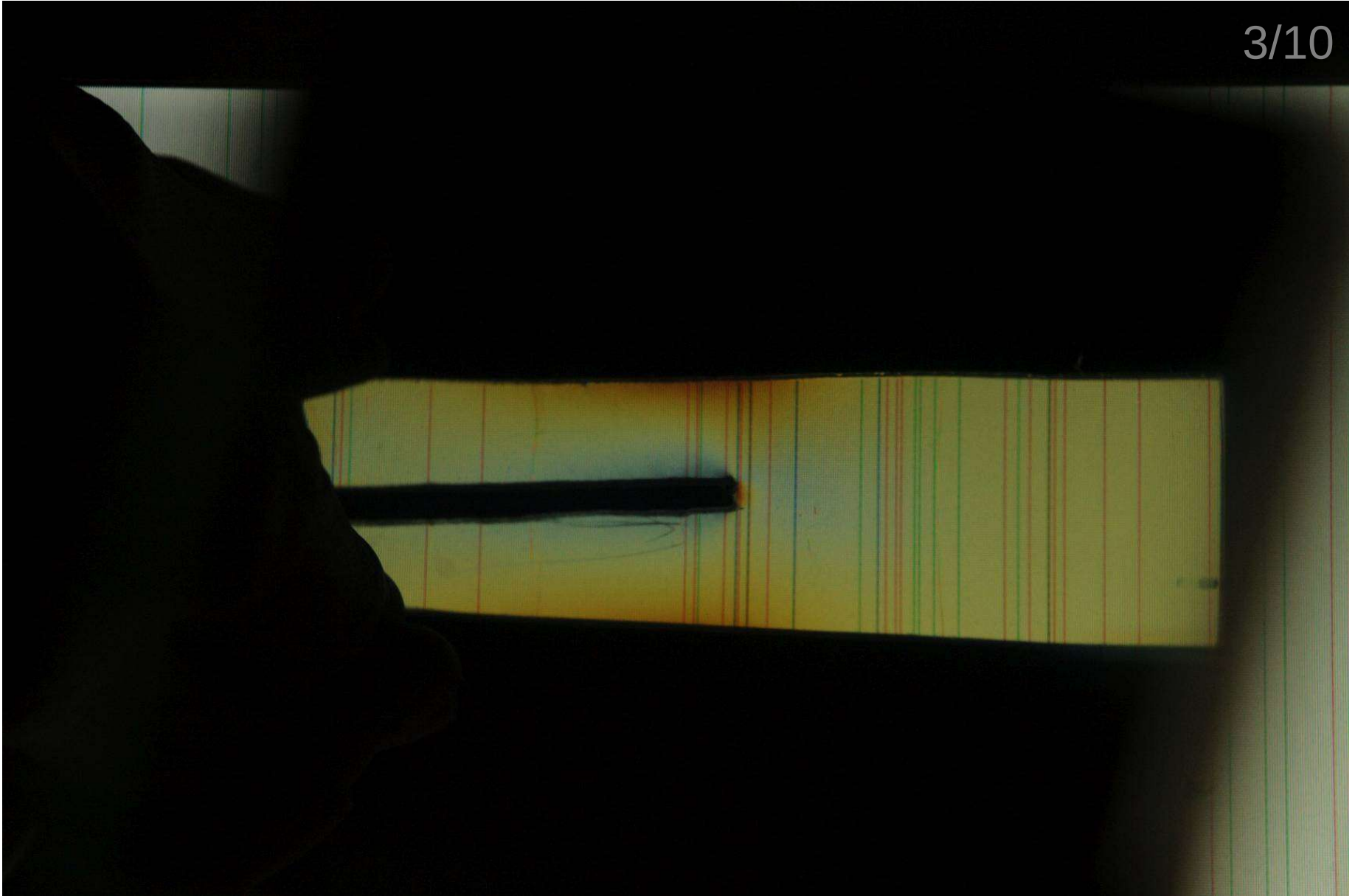
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Postup

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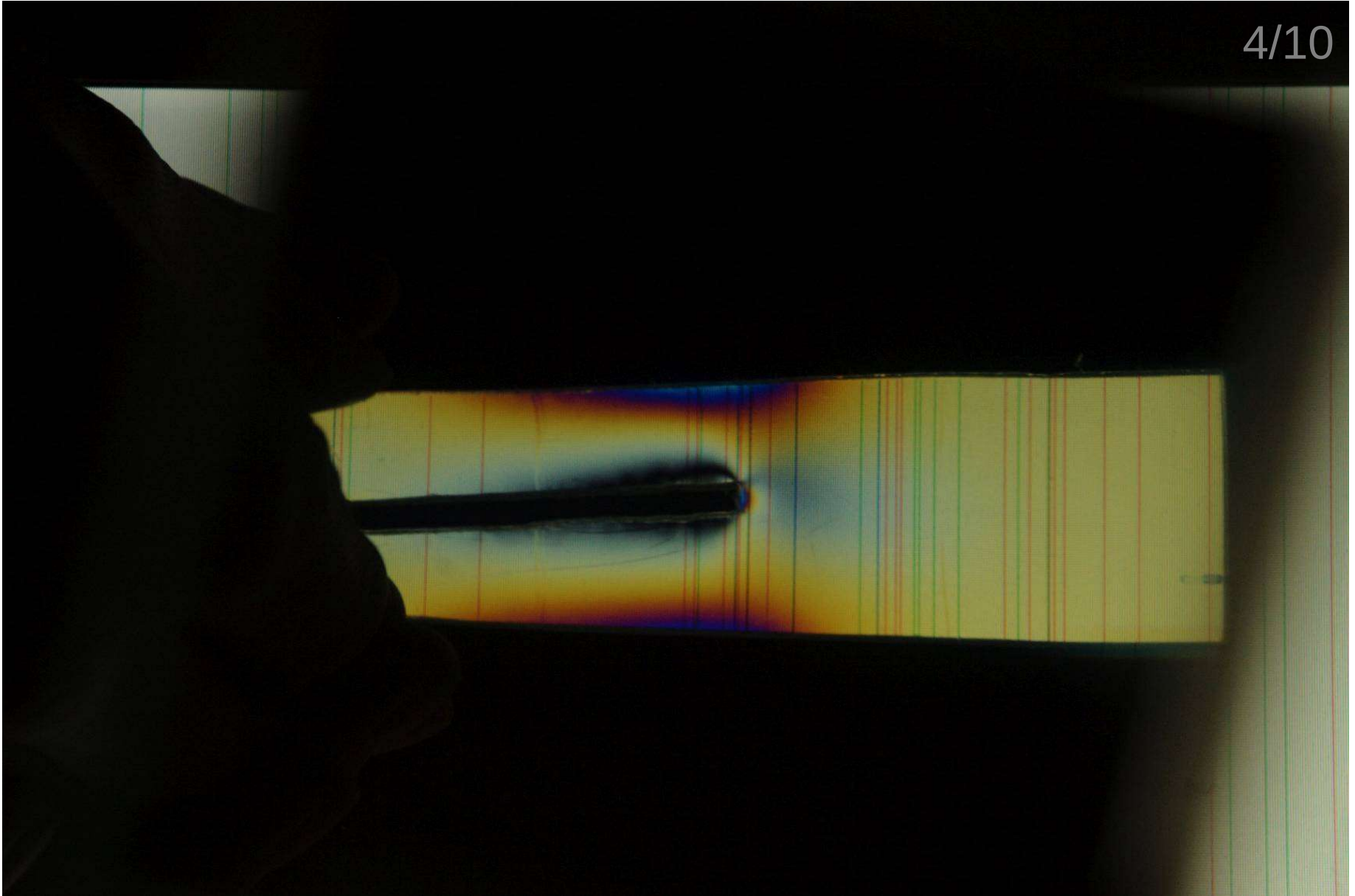
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Postup

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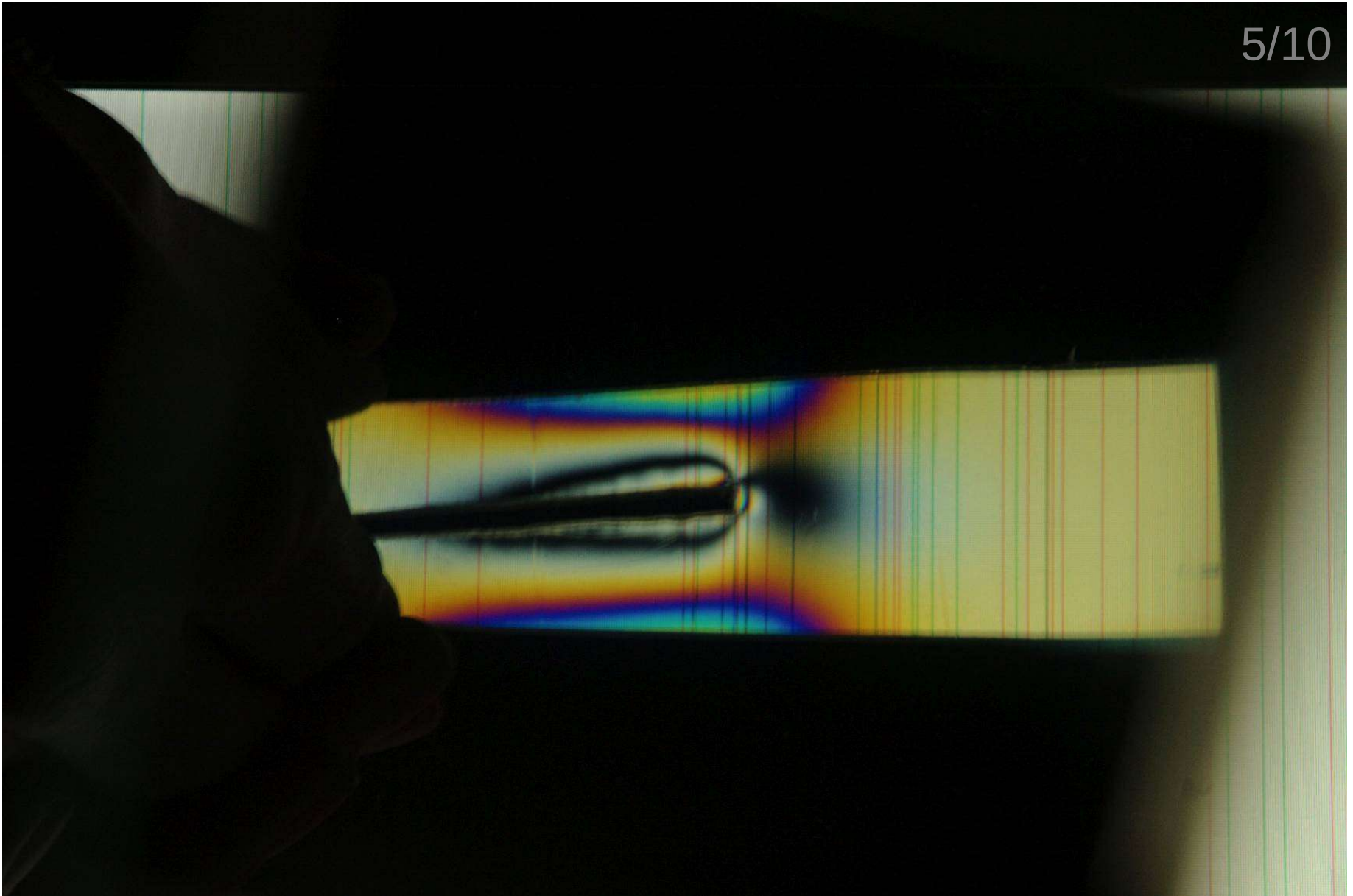
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Postup

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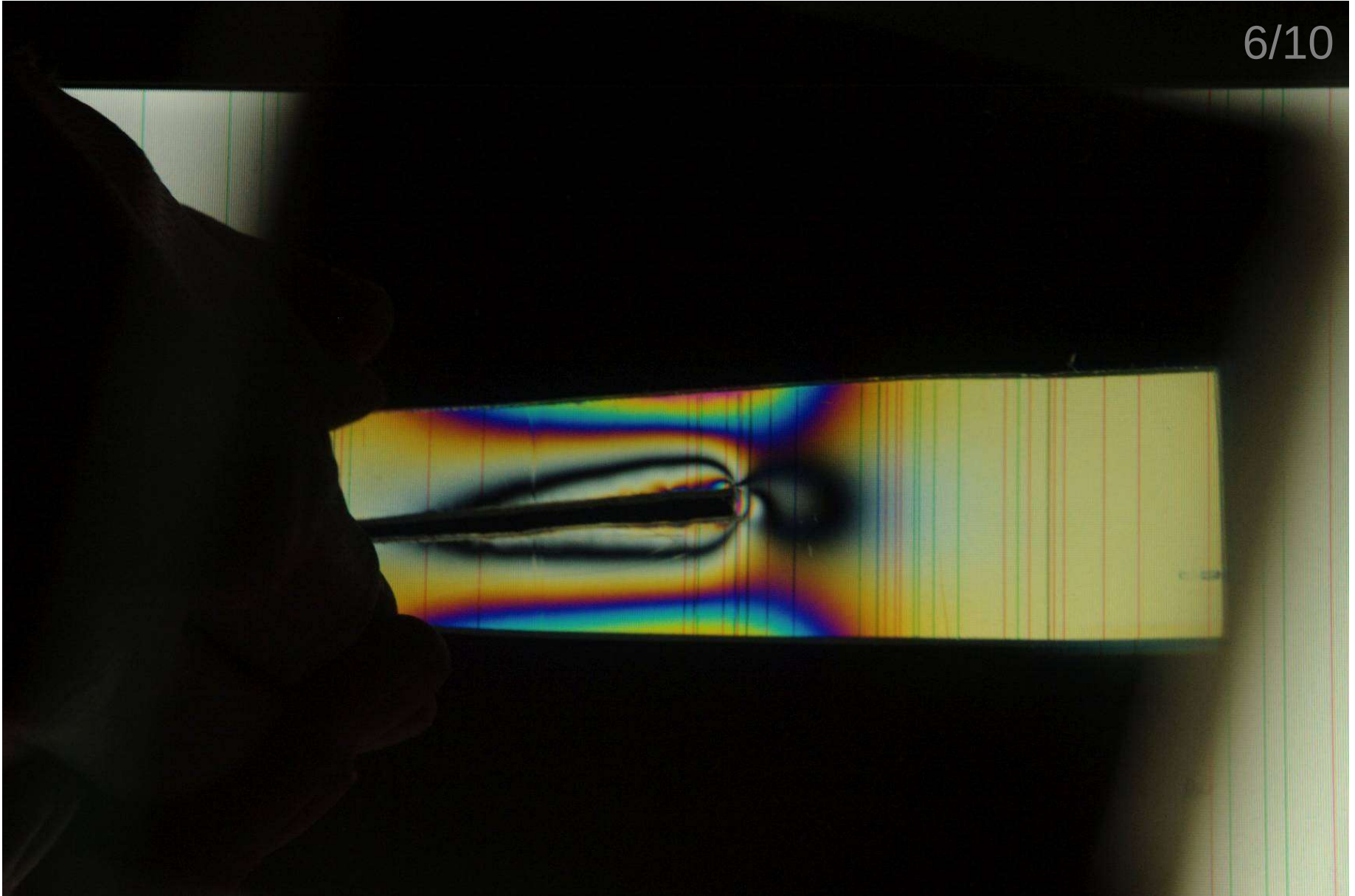
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Postup

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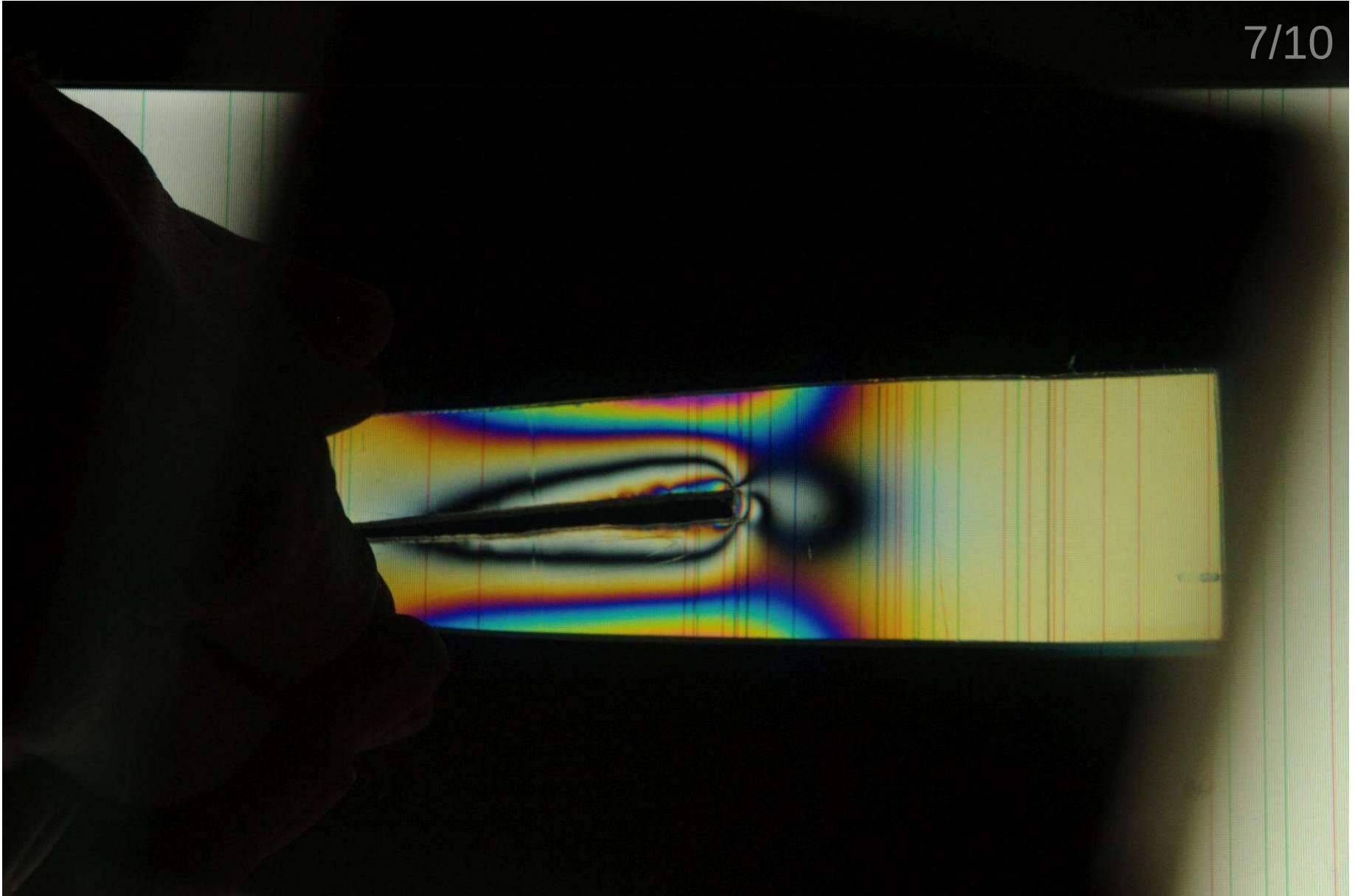
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Postup

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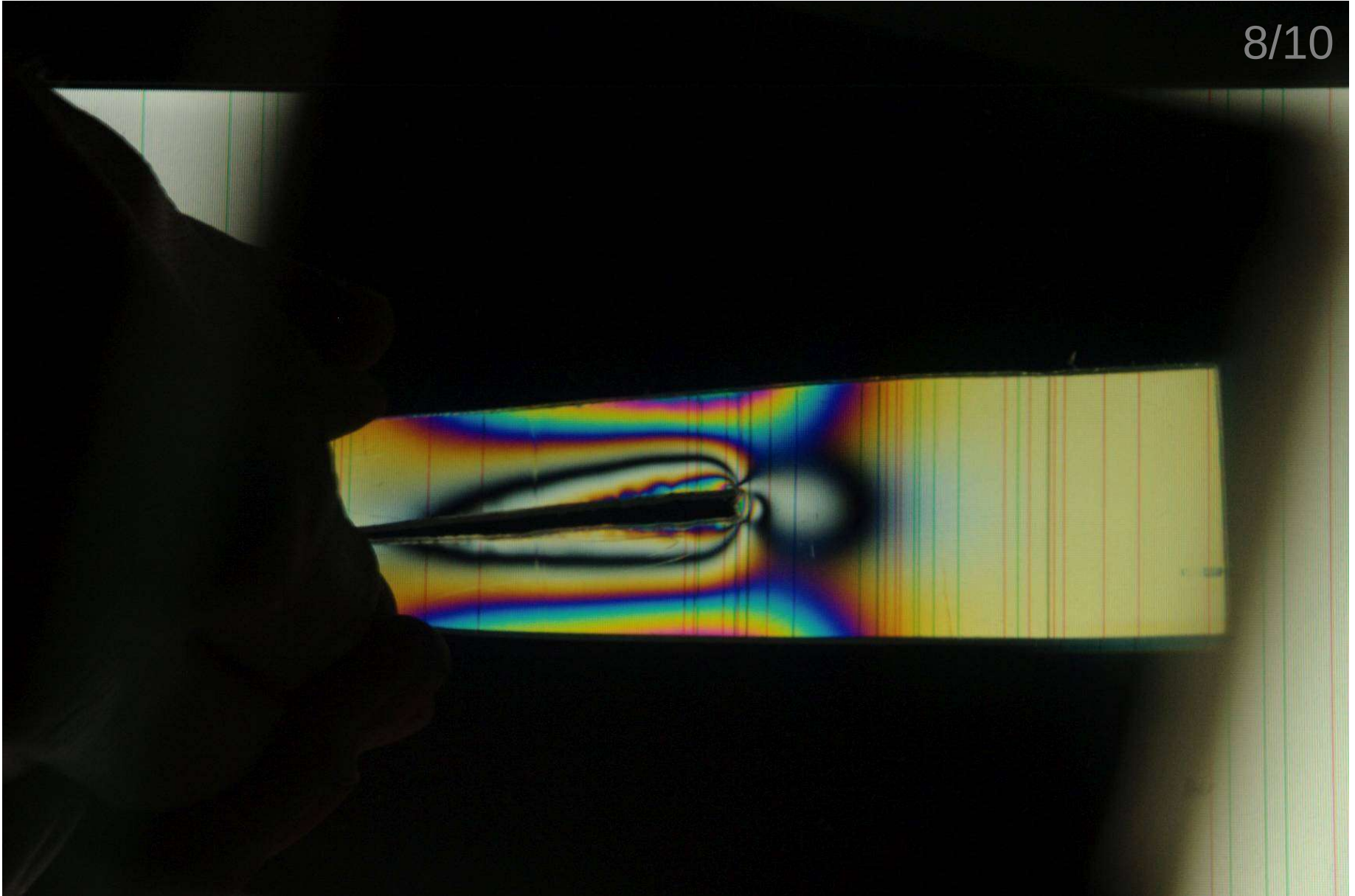
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Postup

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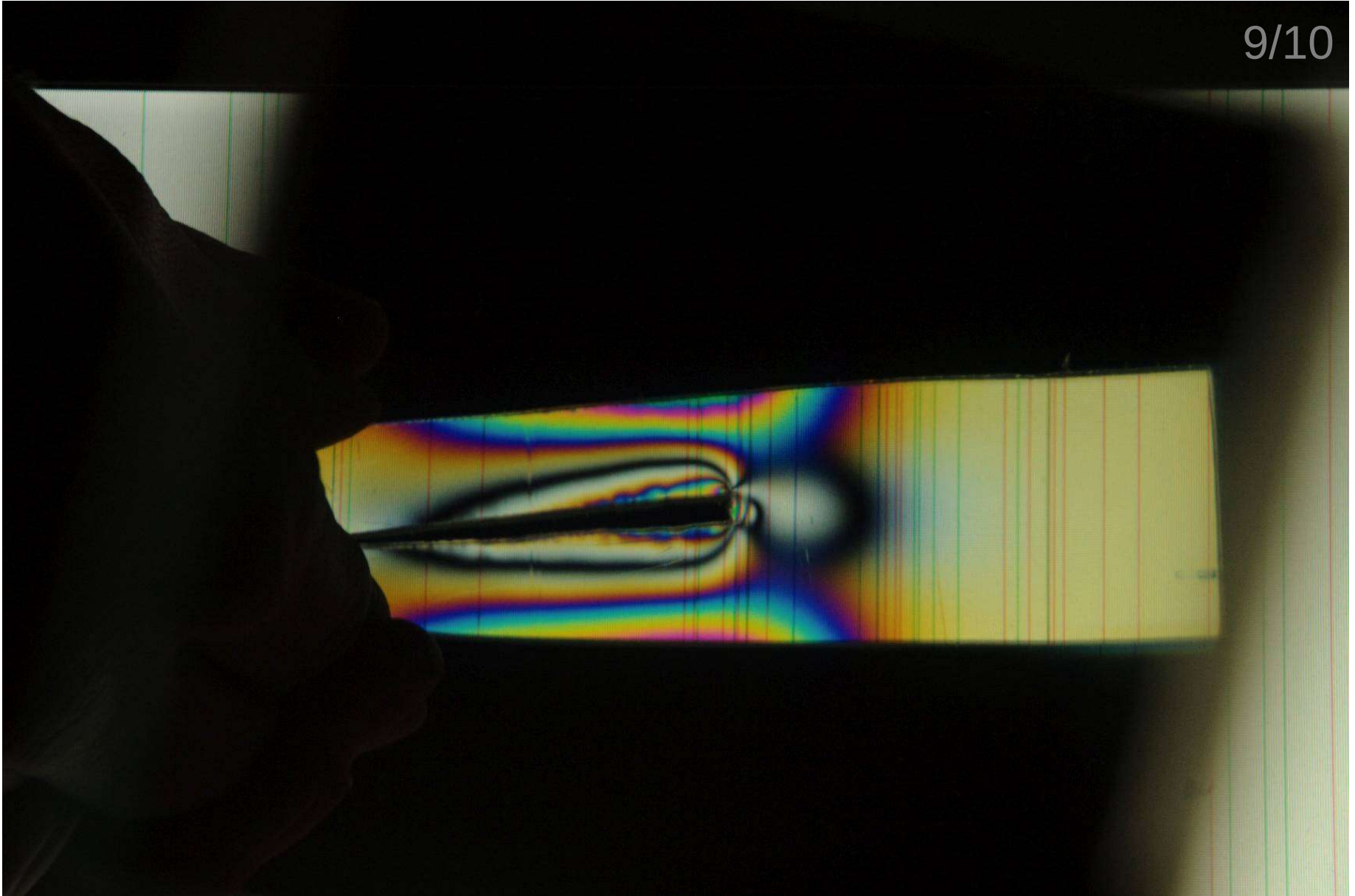
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Postup

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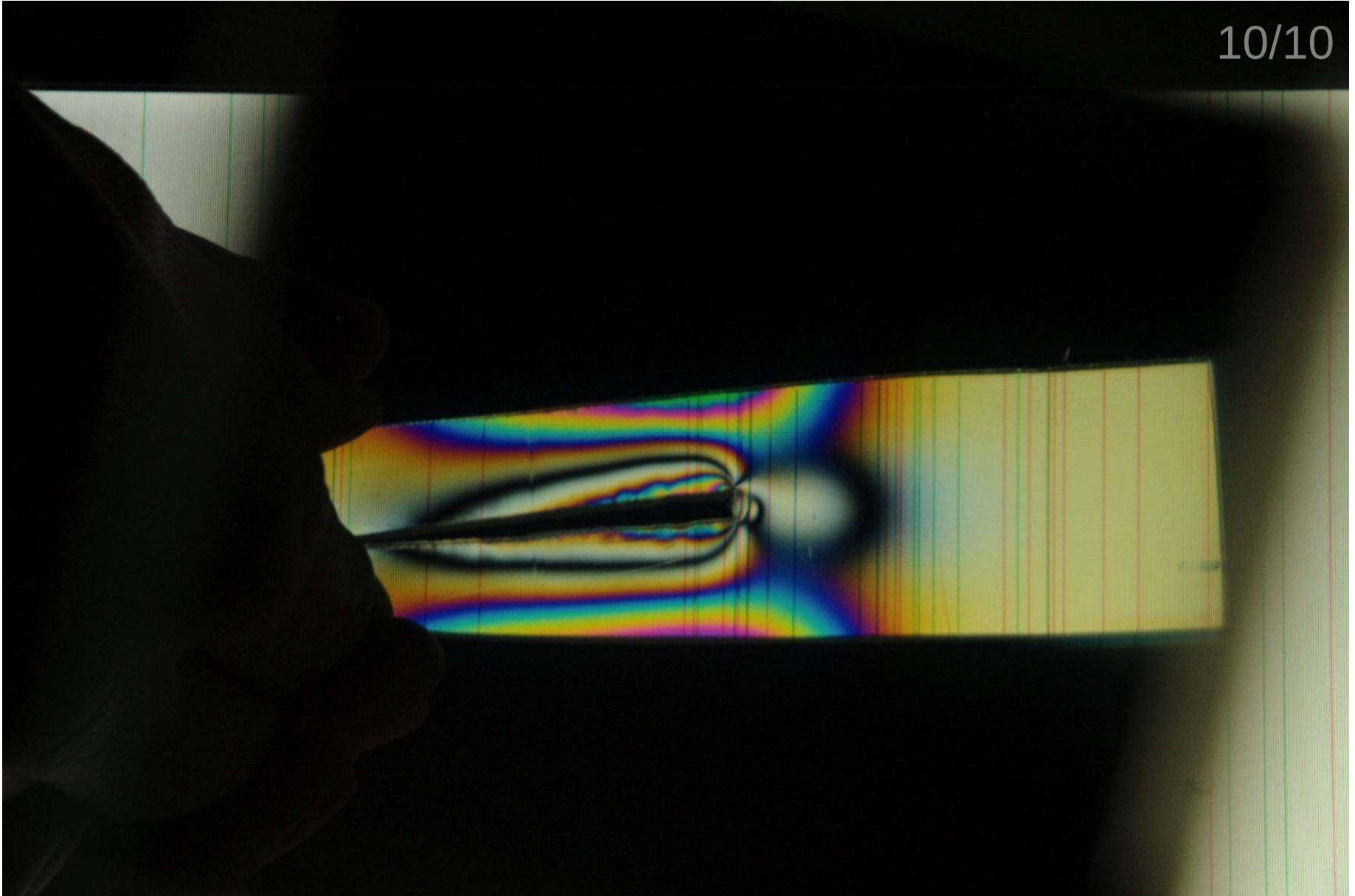
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Postup

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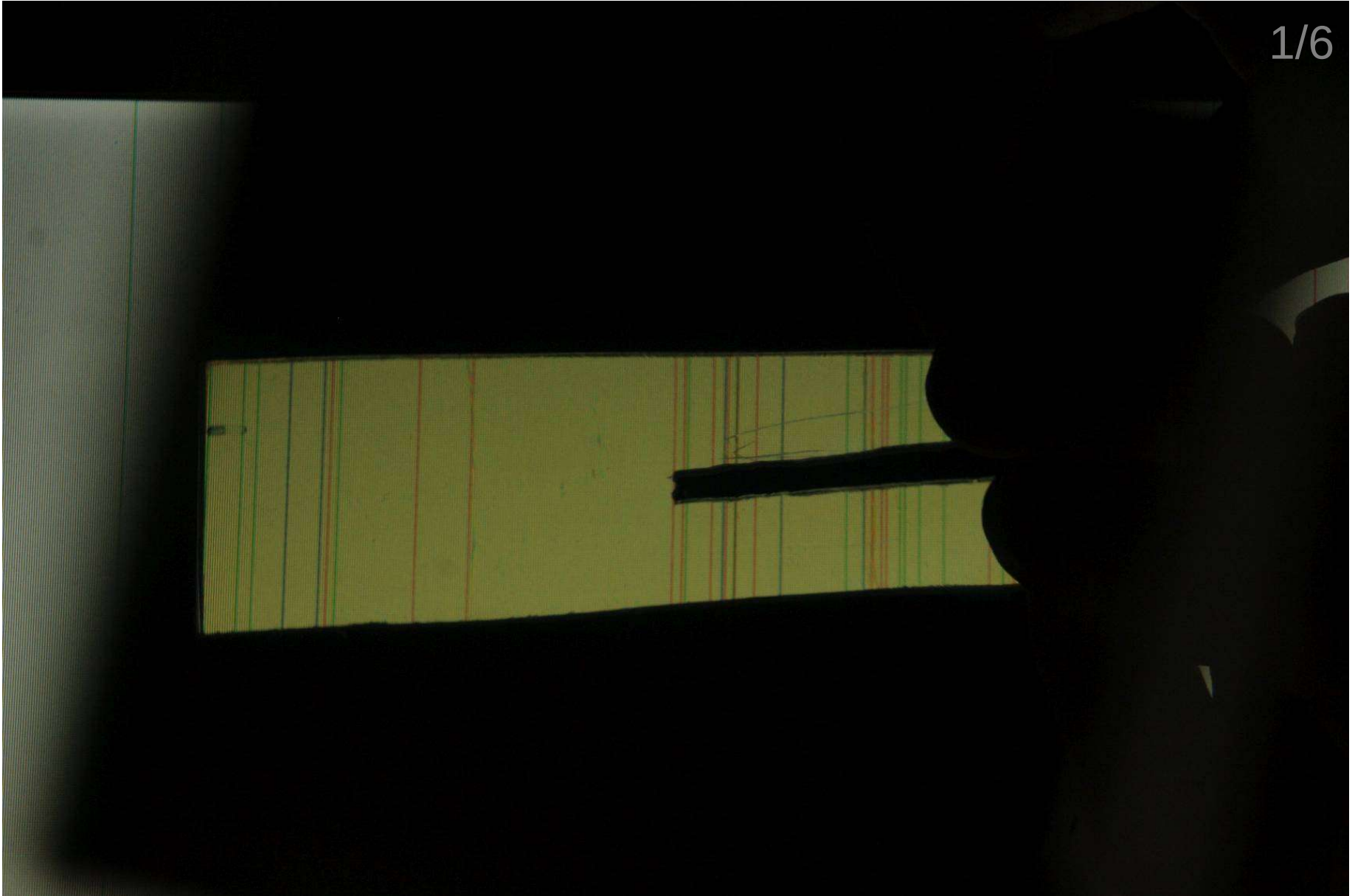
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Postup

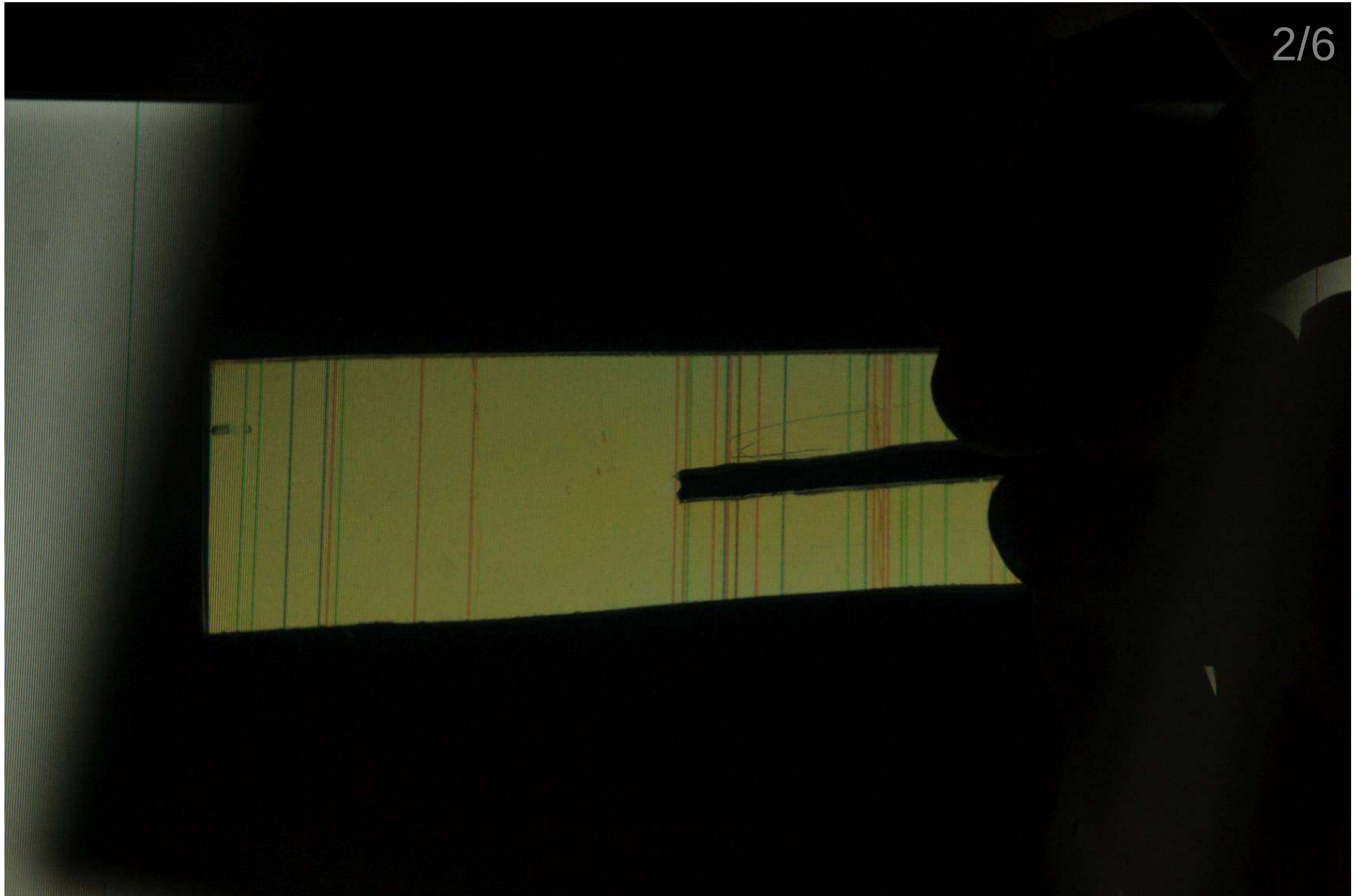
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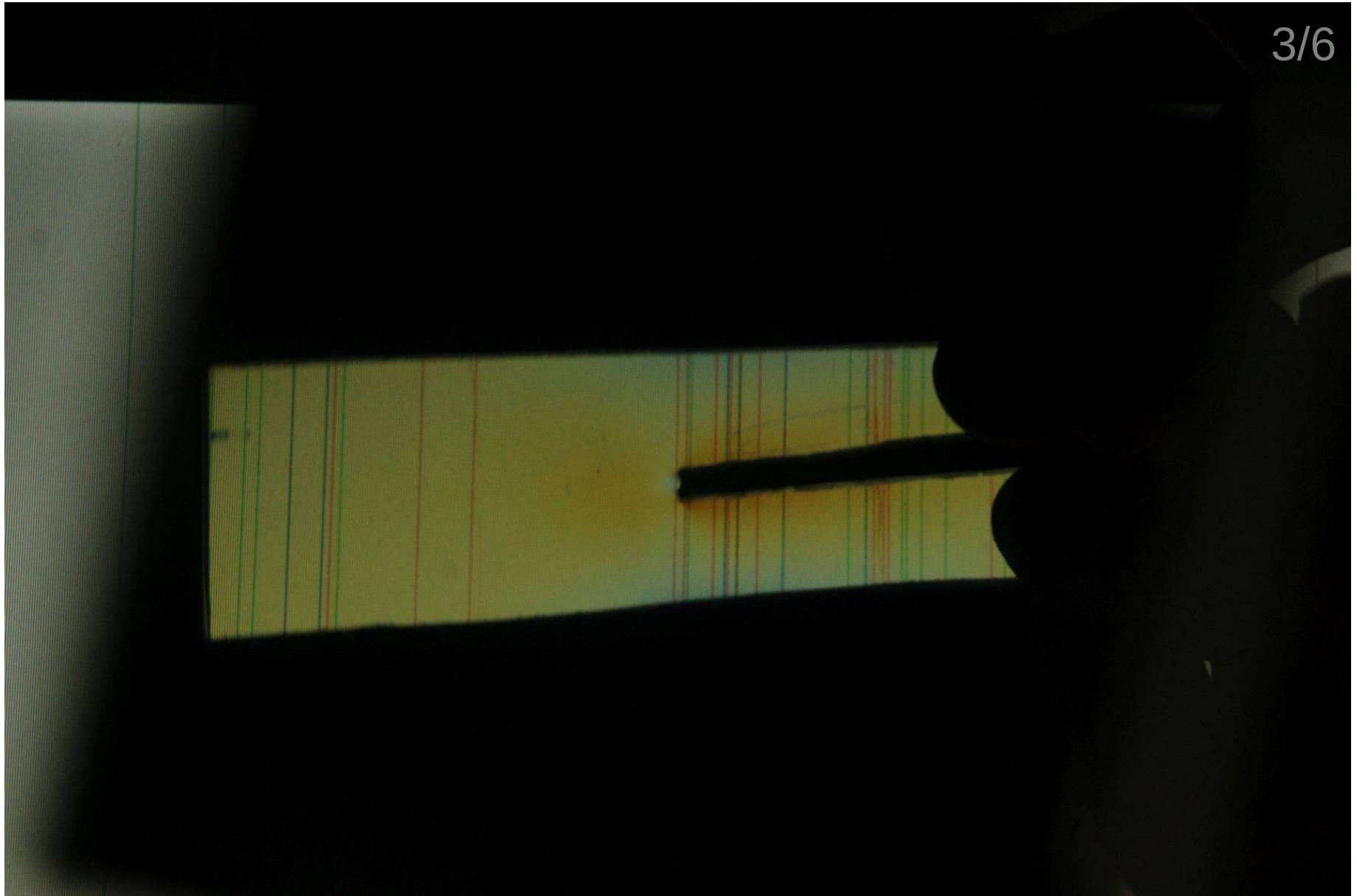
Postup

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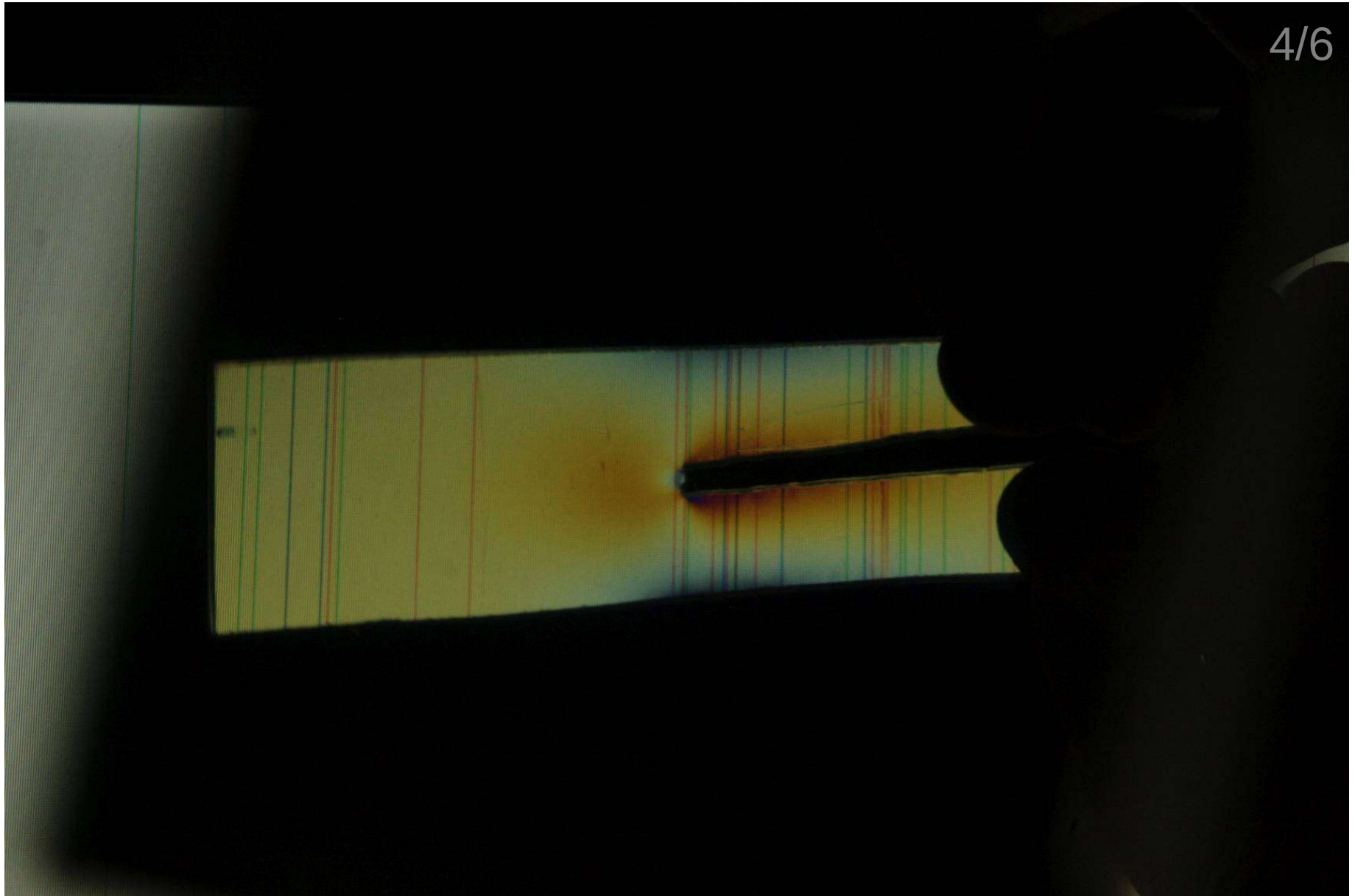
Postup

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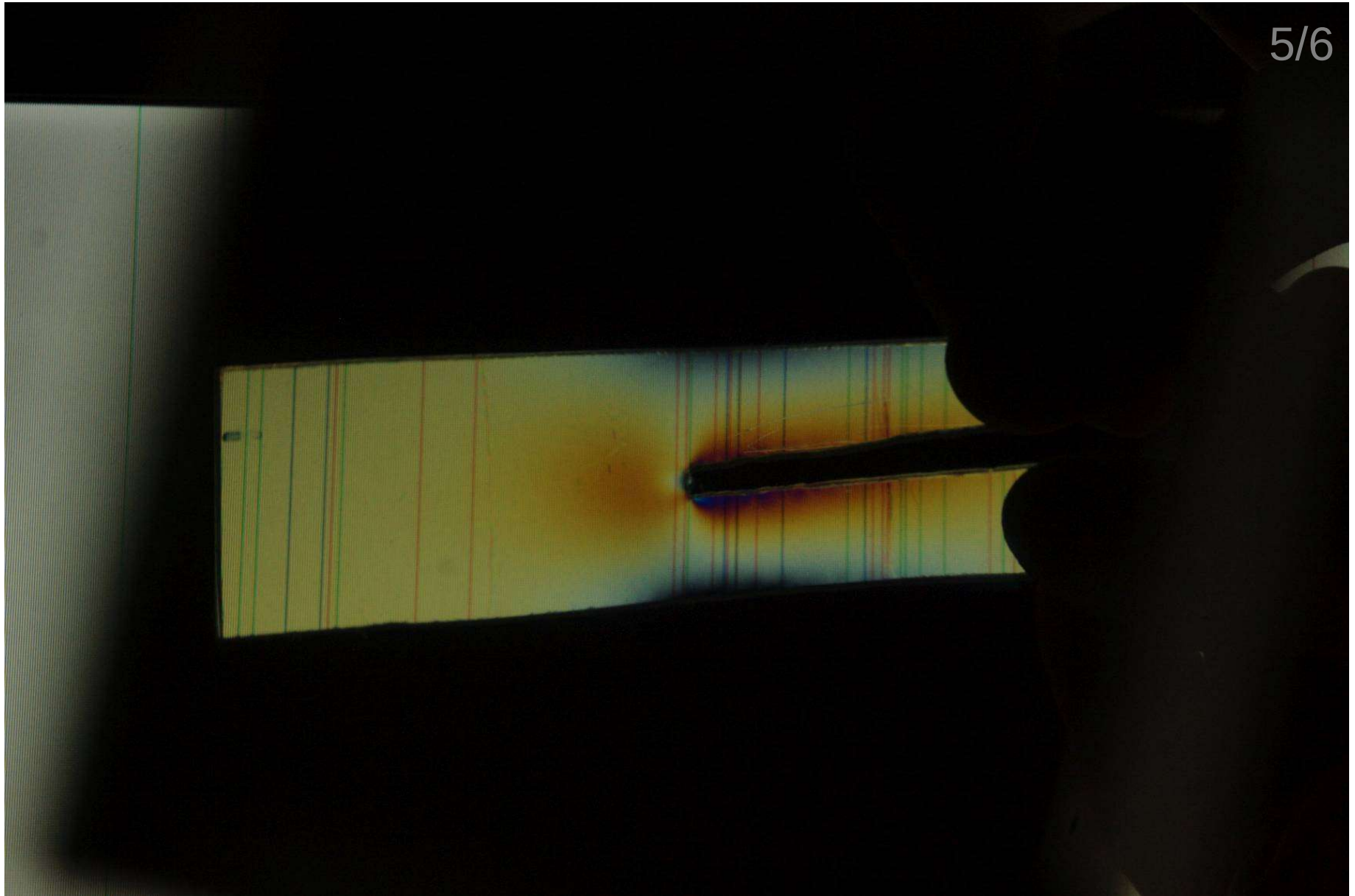
Postup

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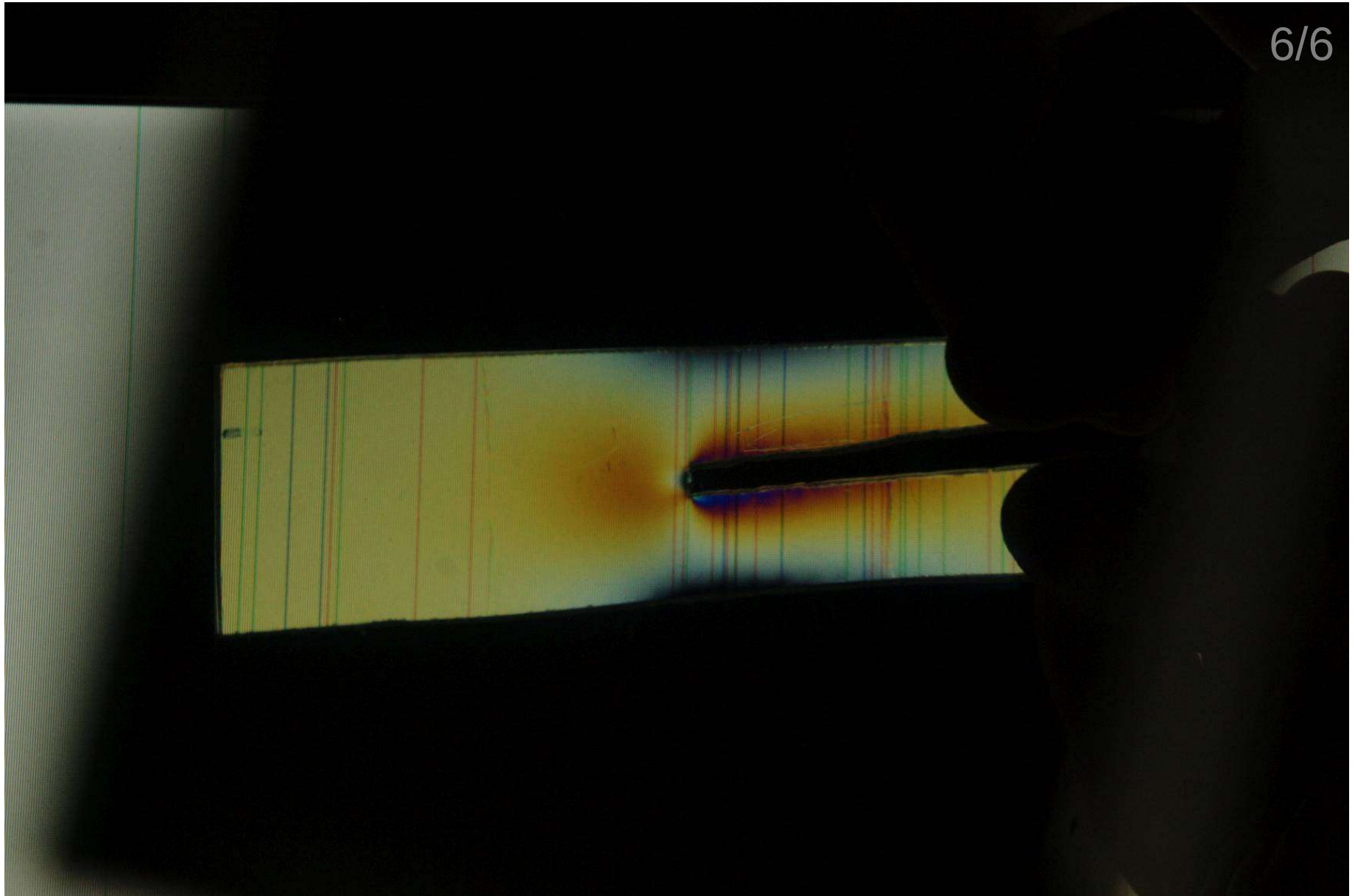
Postup

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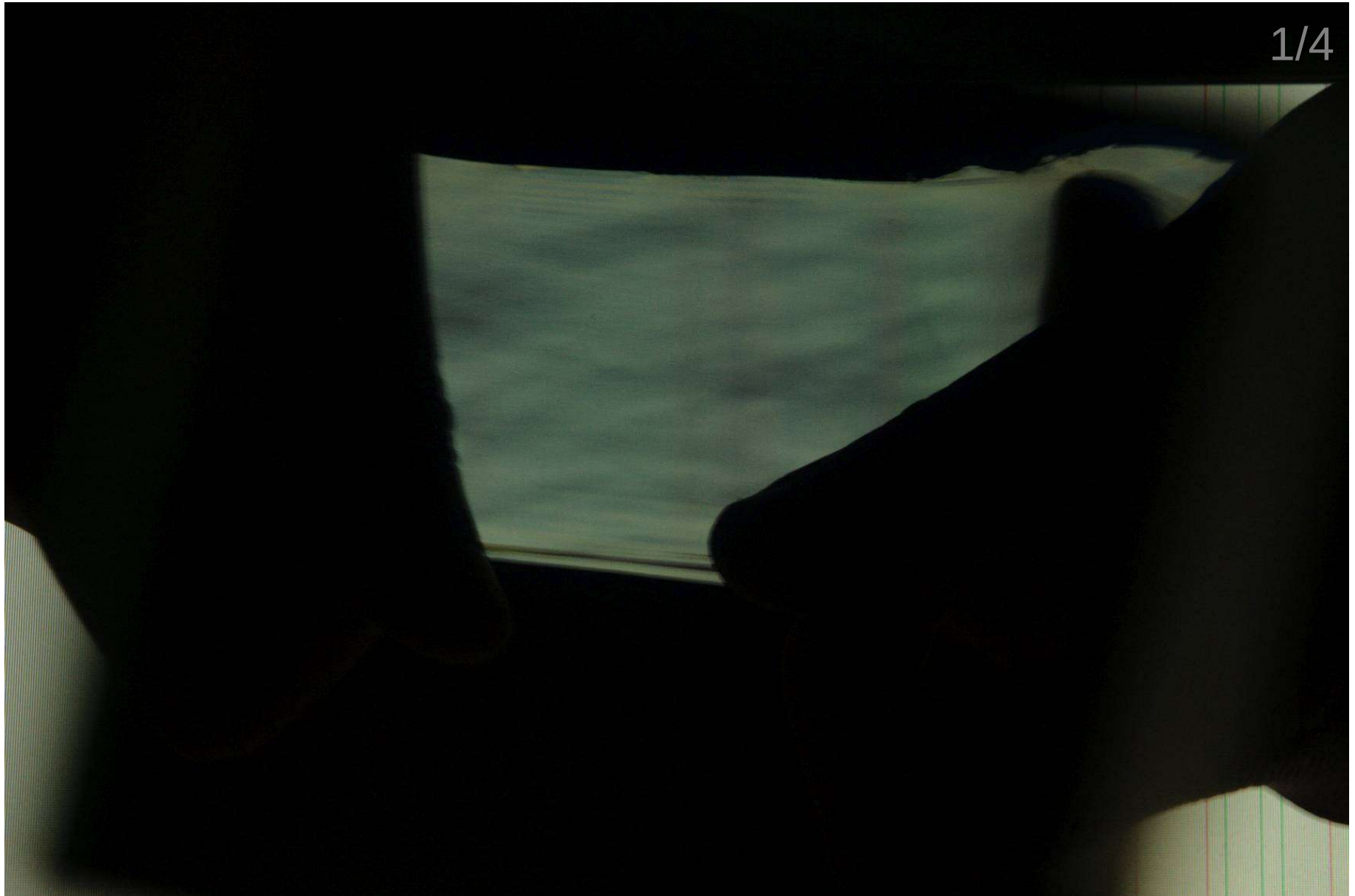
Postup

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Postup

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Postup

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Postup

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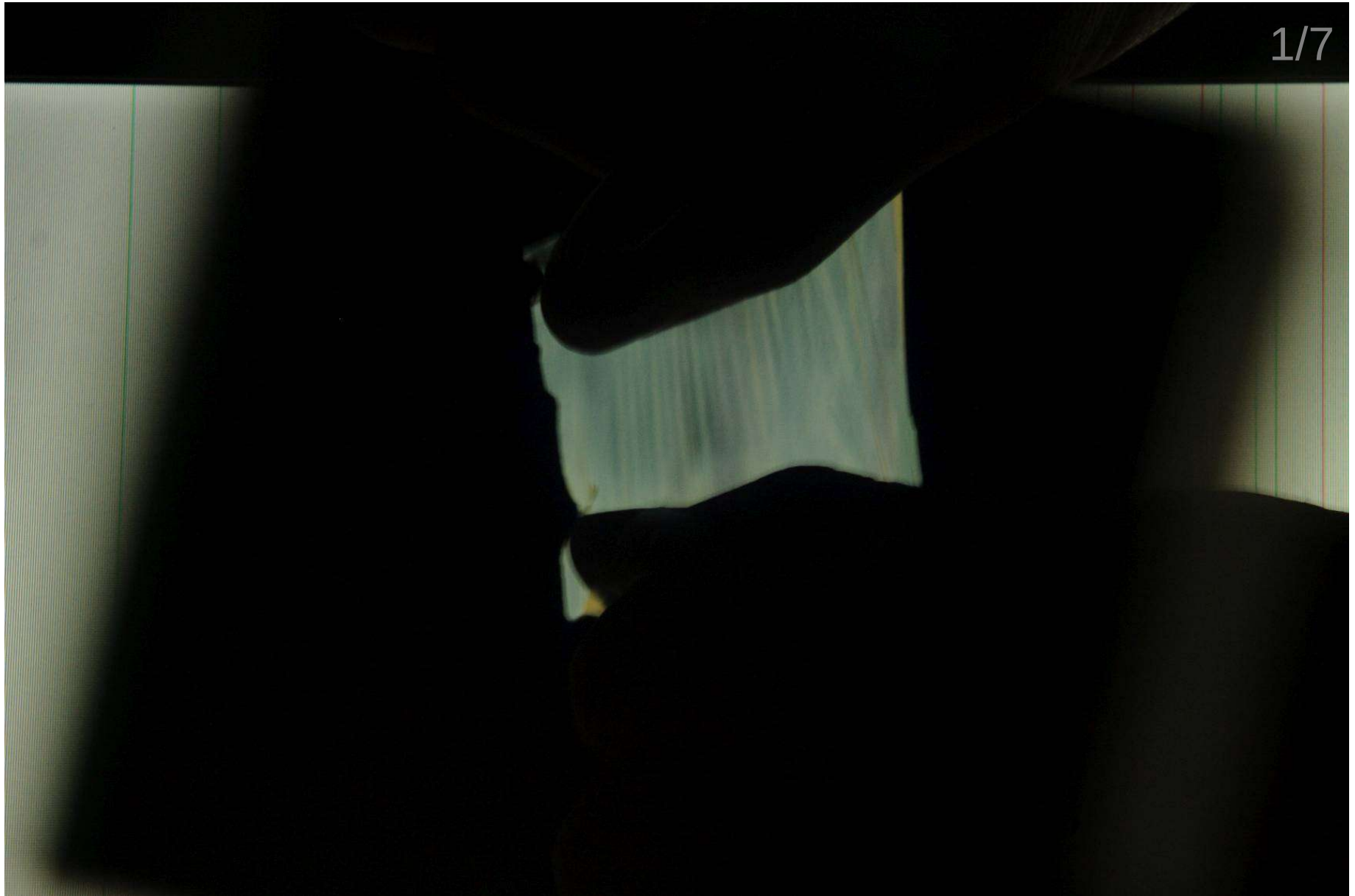
Postup

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Postup

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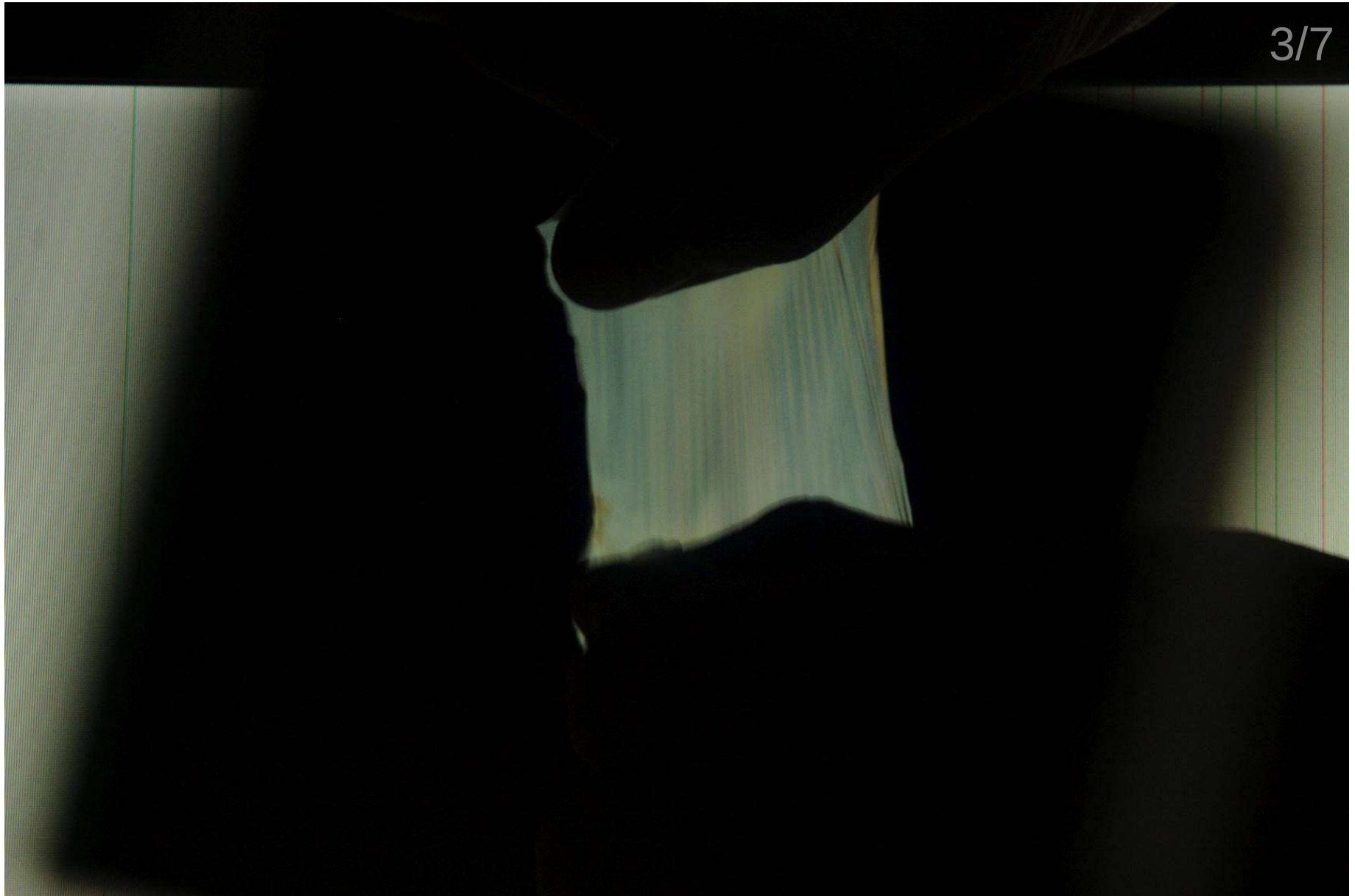
Postup

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Postup

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Postup

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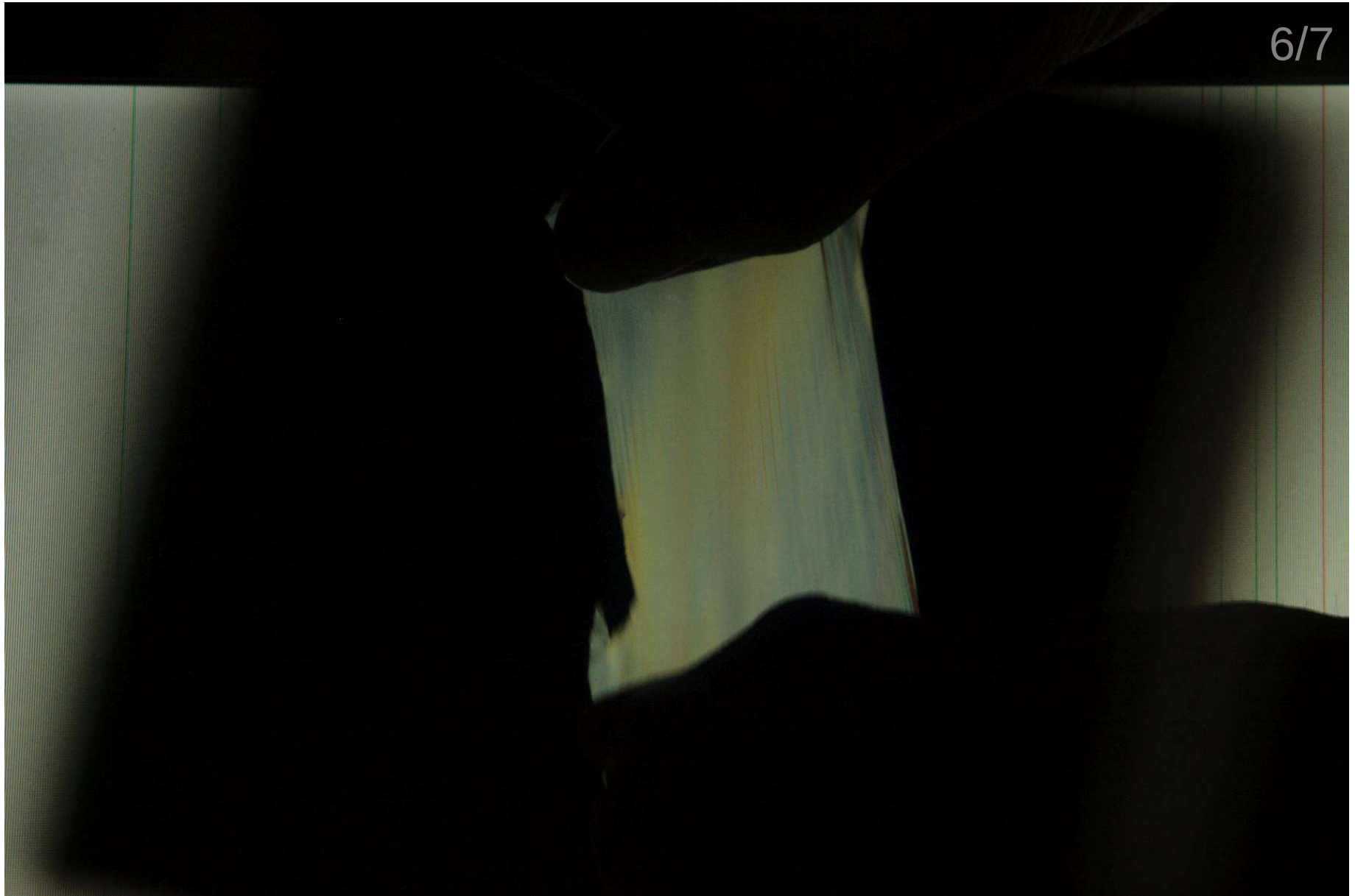
Postup

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Postup

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Postup

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Obsah

Velikost

Teplotní roztažnost

Mechanické napětí

Rotace země

Foucaultovo kejevadlo

Pomůcky

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fot'ák, stativ

Foucaultovo kyvadlo: závaží, hřebíky, špagát, kus dřeva,
(vrtačka, páječka, ...)

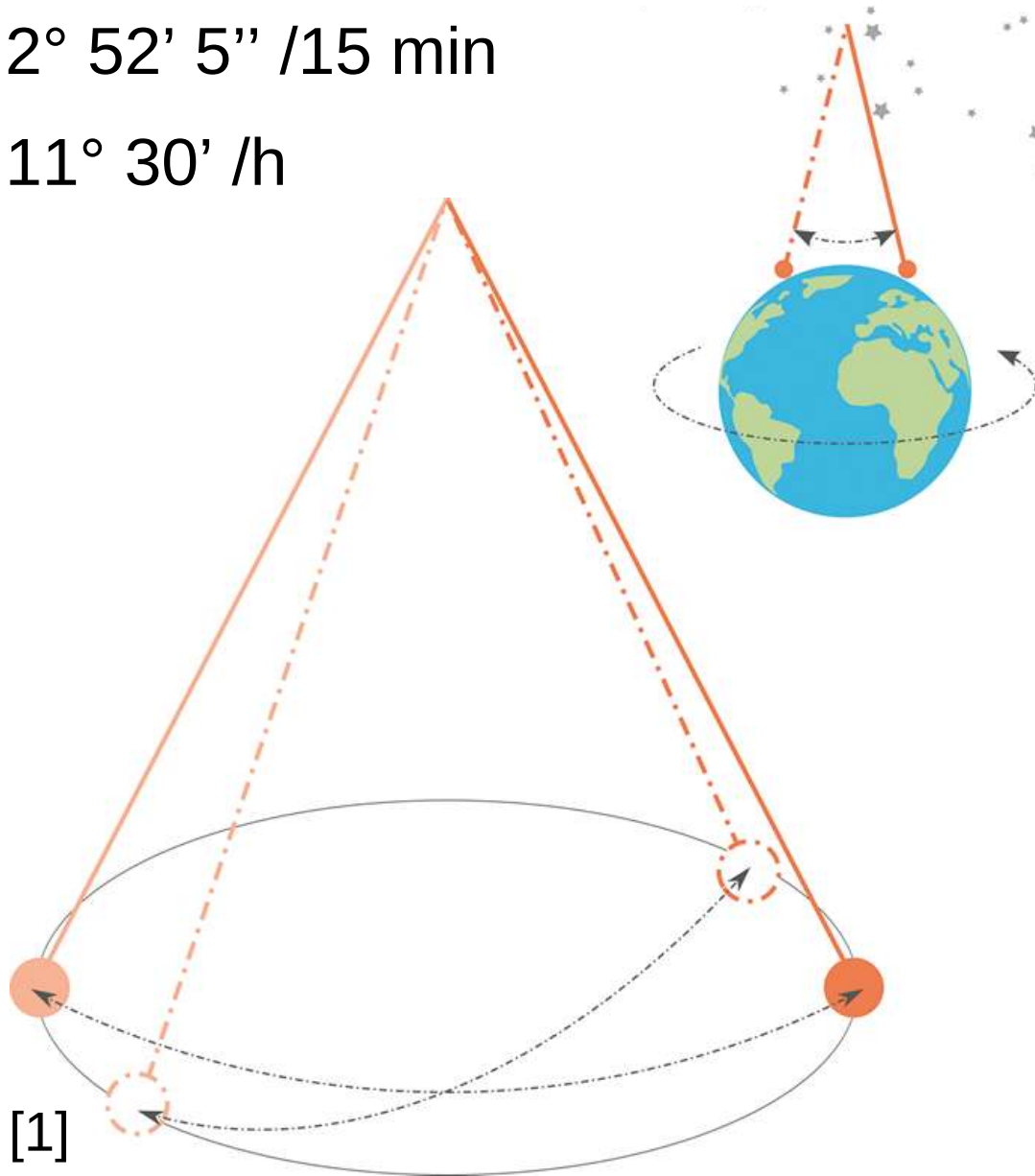
RGB LED, programovatelný modul

(svítilna, stopky, ...)

Postup

$2^{\circ} 52' 5'' / 15 \text{ min}$

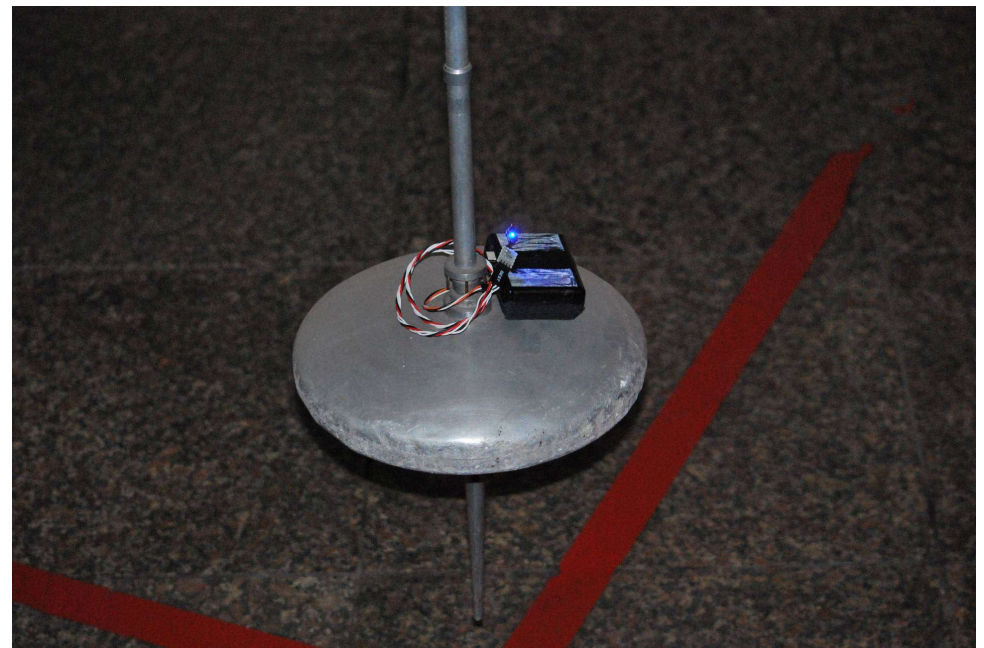
$11^{\circ} 30' / \text{h}$



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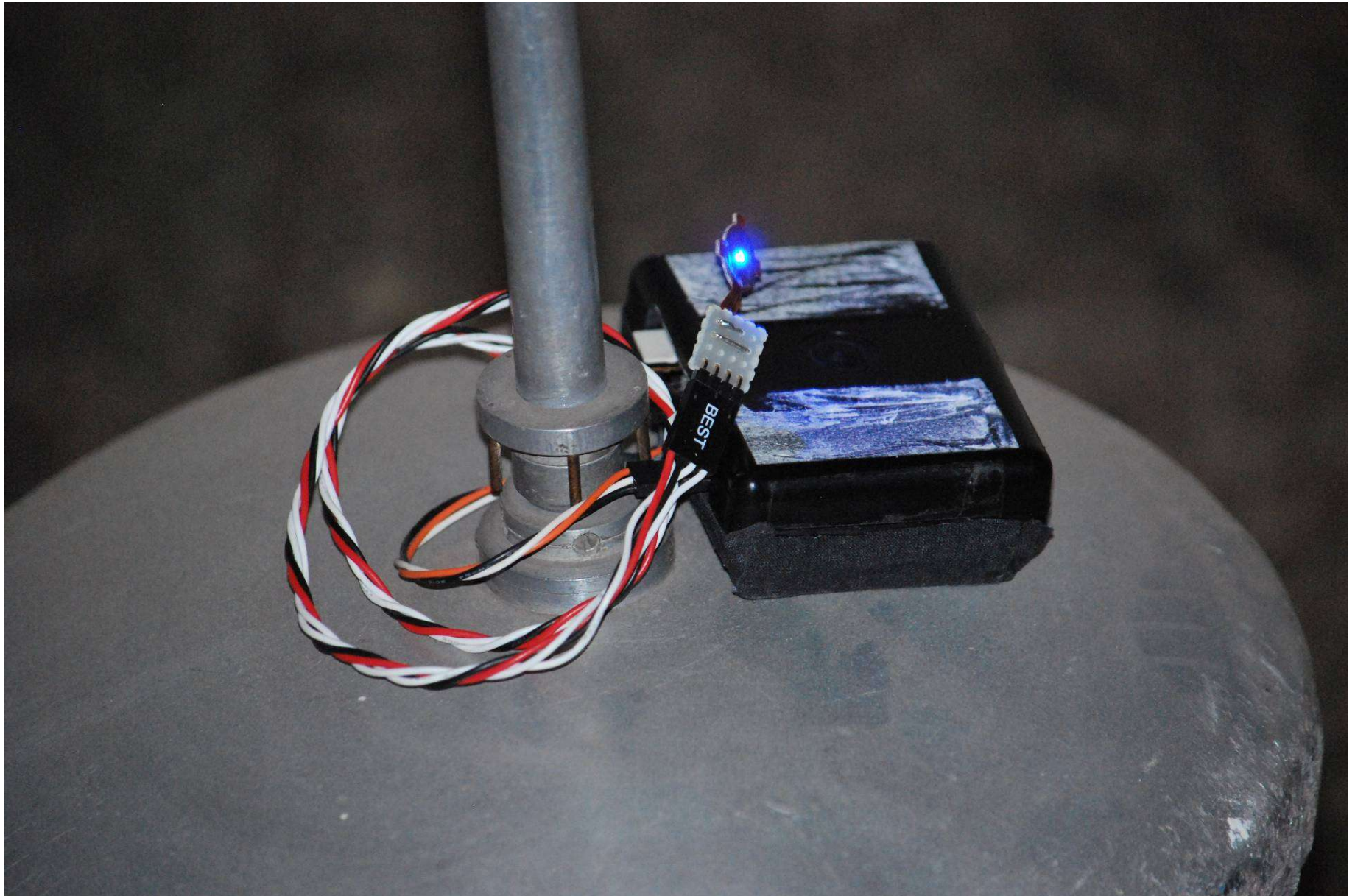
Postup

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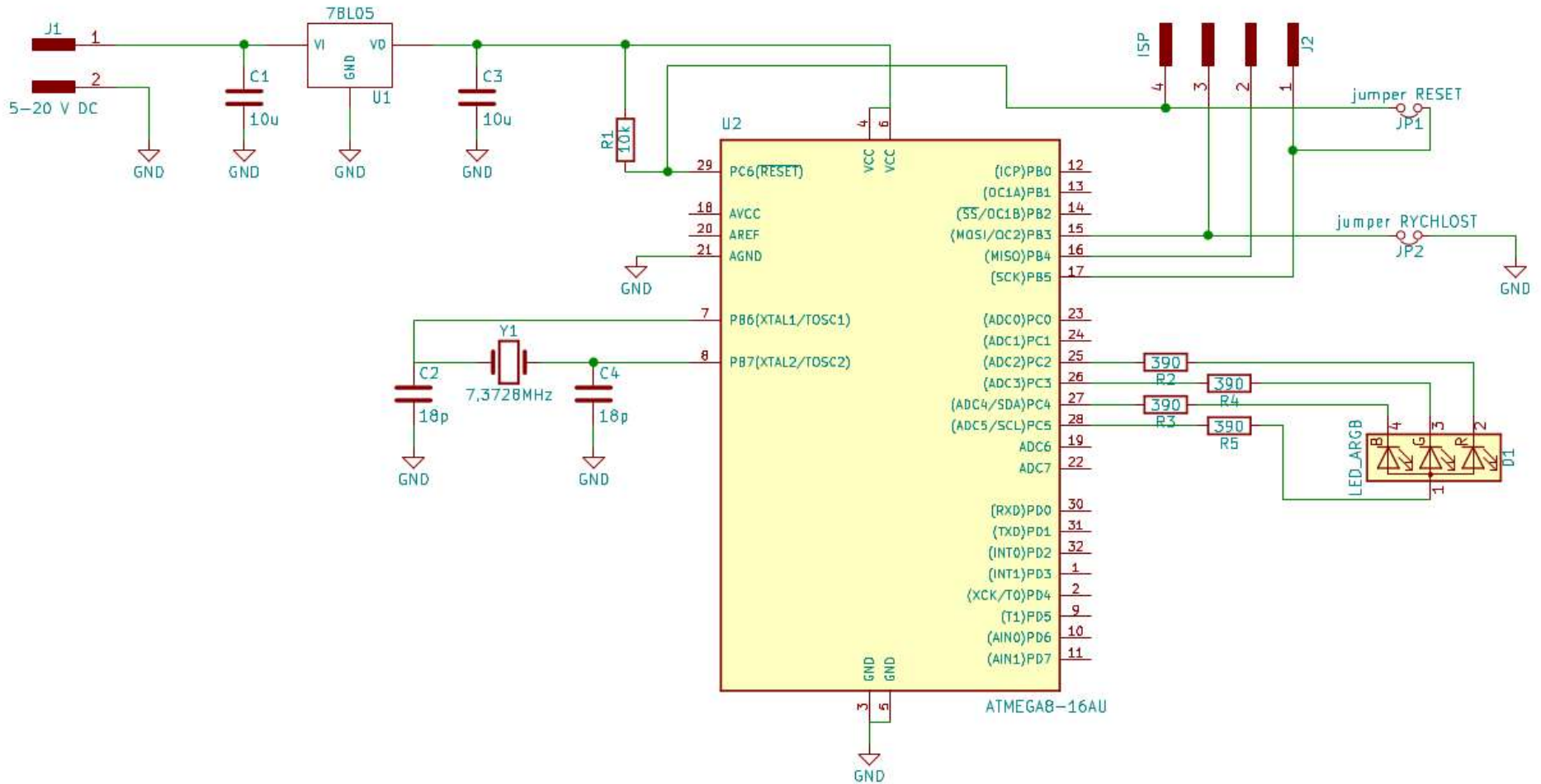
Postup

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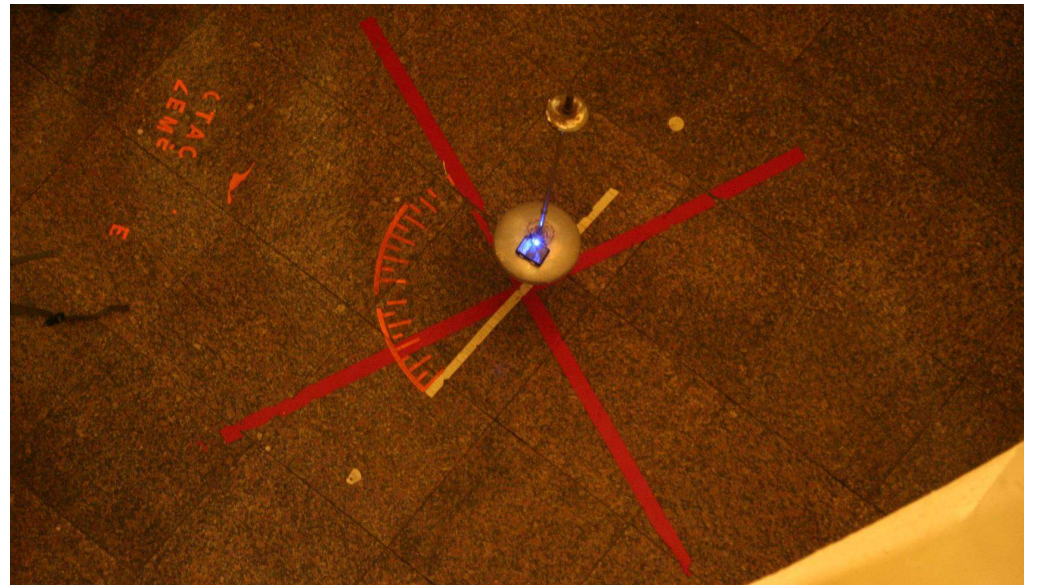
Postup

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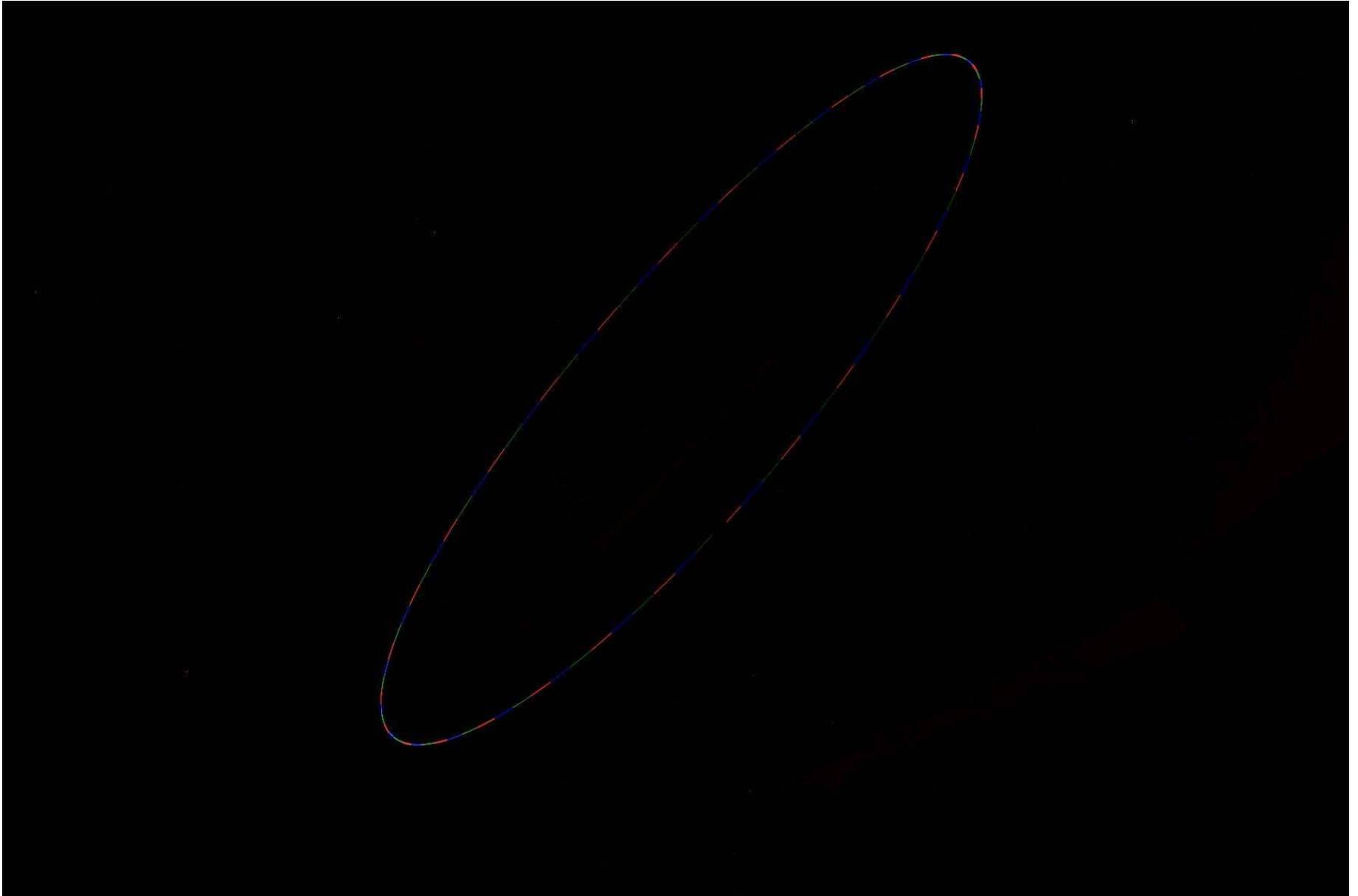
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Postup

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Postup

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Postup

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Postup

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Postup

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Postup

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Postup

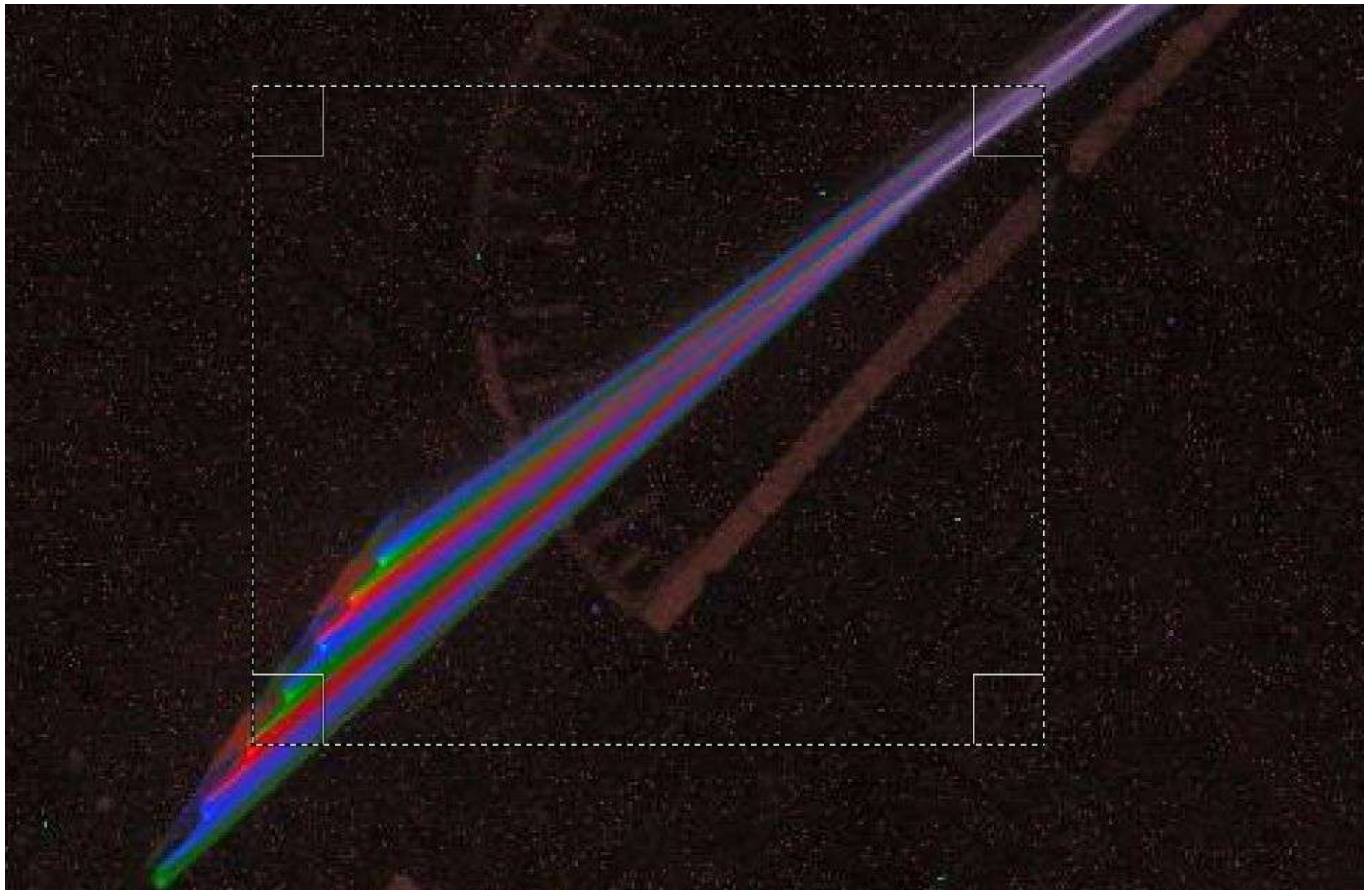
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Postup

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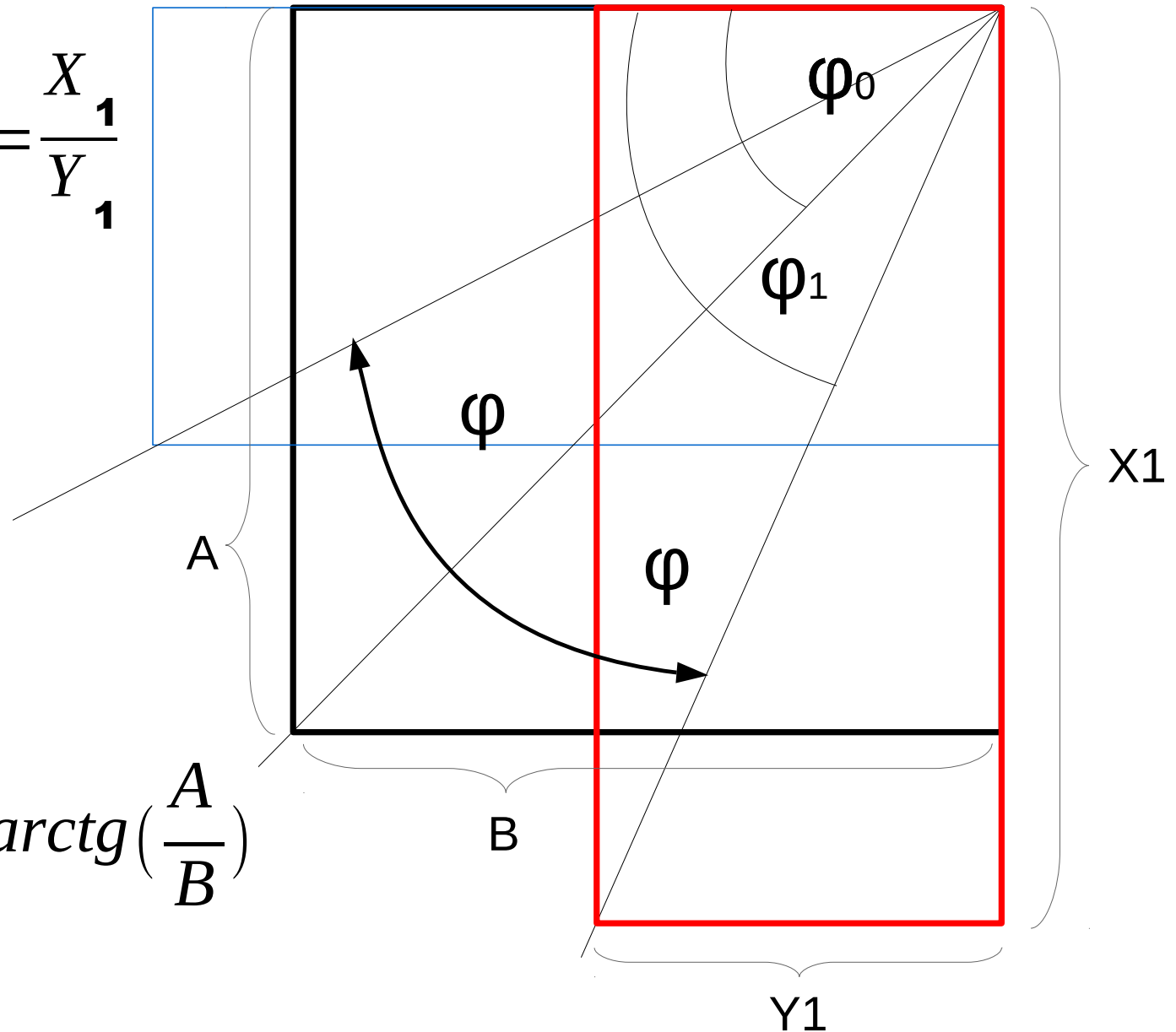
Postup

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$$\operatorname{tg} \varphi_0 = \frac{A}{B} \quad \operatorname{tg} \varphi_1 = \frac{X_1}{Y_1}$$

$$\varphi = \varphi_1 - \varphi_0$$

$$\varphi = \operatorname{arctg} \left(\frac{X_1}{Y_1} \right) - \operatorname{arctg} \left(\frac{A}{B} \right)$$



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$$T = \frac{360^\circ}{4 \bar{\varphi}} \cdot \sin(50^\circ 4,67') [h] \quad [3]$$

T... čas otočení Země kolem osy $\bar{\varphi}$.. průměr φ za 15 minut

průměr φ za prvních 15 min

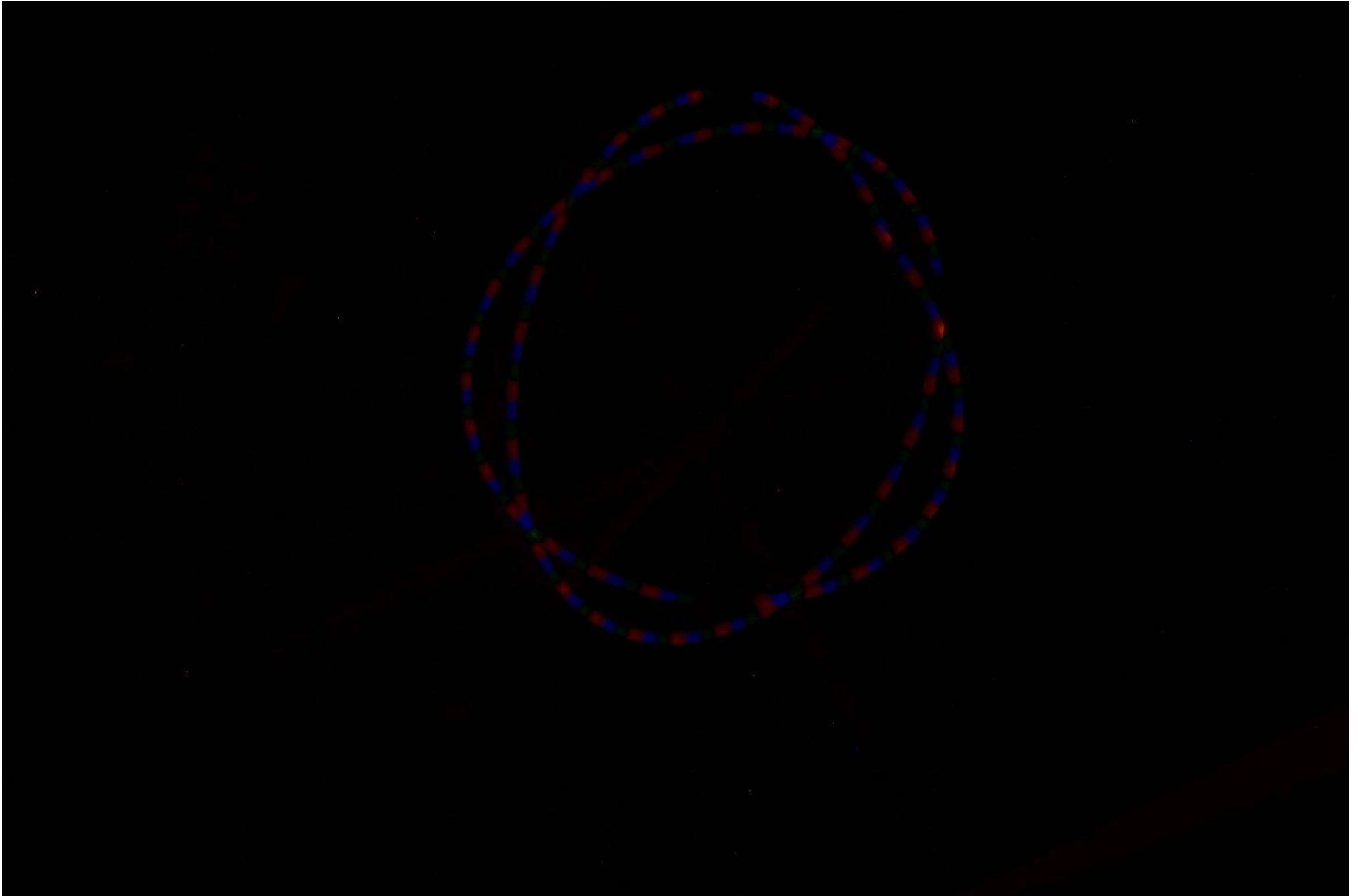
$$\bar{\varphi} = 3^\circ 8' 13'' \quad T = 22 \text{ h } 0 \text{ min}$$

průměr φ za dalších 15 min

$$\bar{\varphi} = 3^\circ 0' 0'' \quad T = 23 \text{ h } 0 \text{ min}$$

Postup

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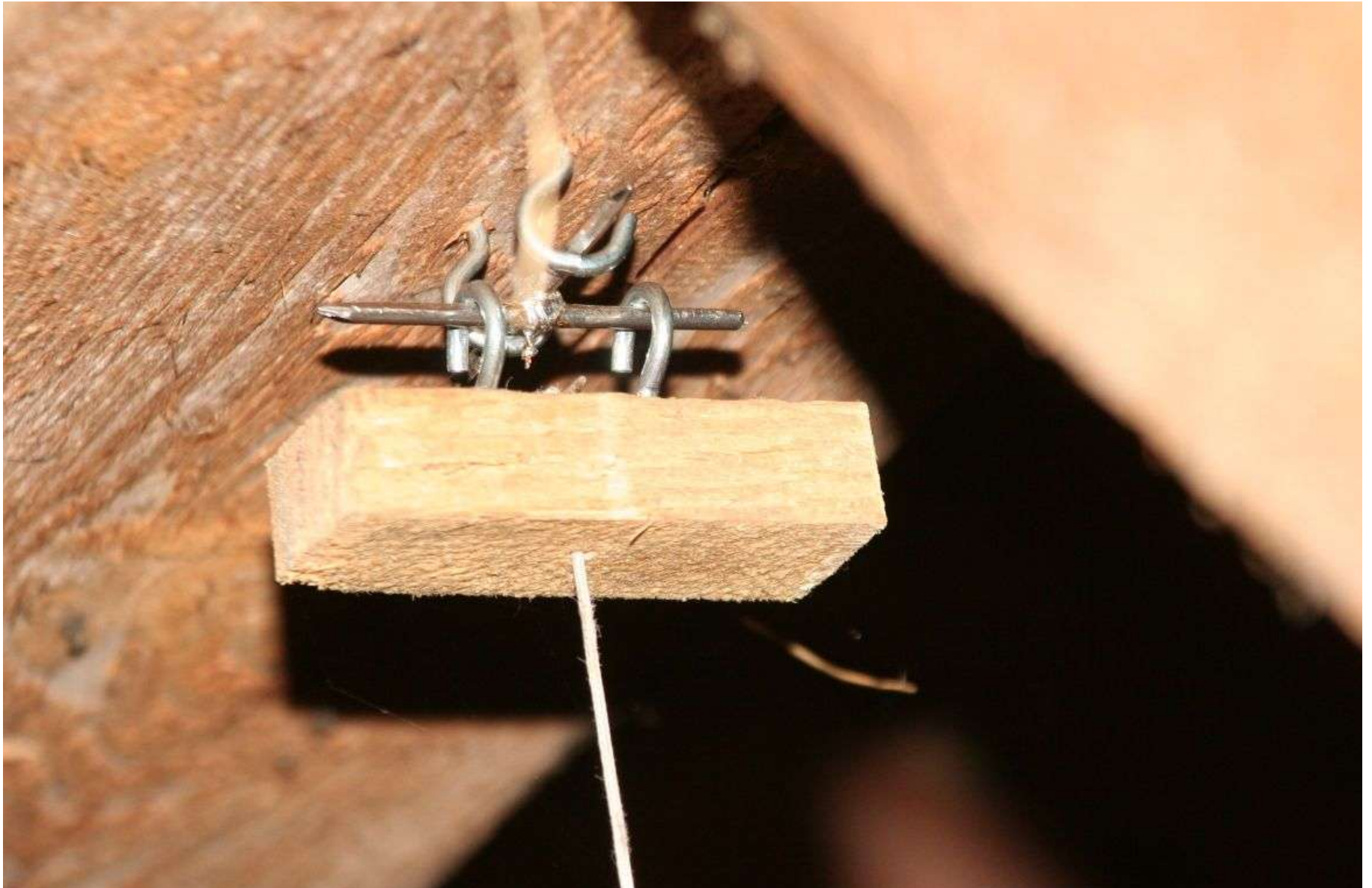
Postup

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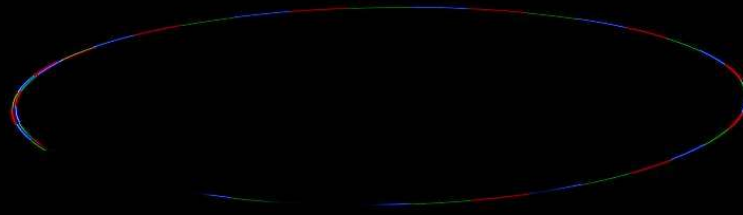
Postup

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Postup

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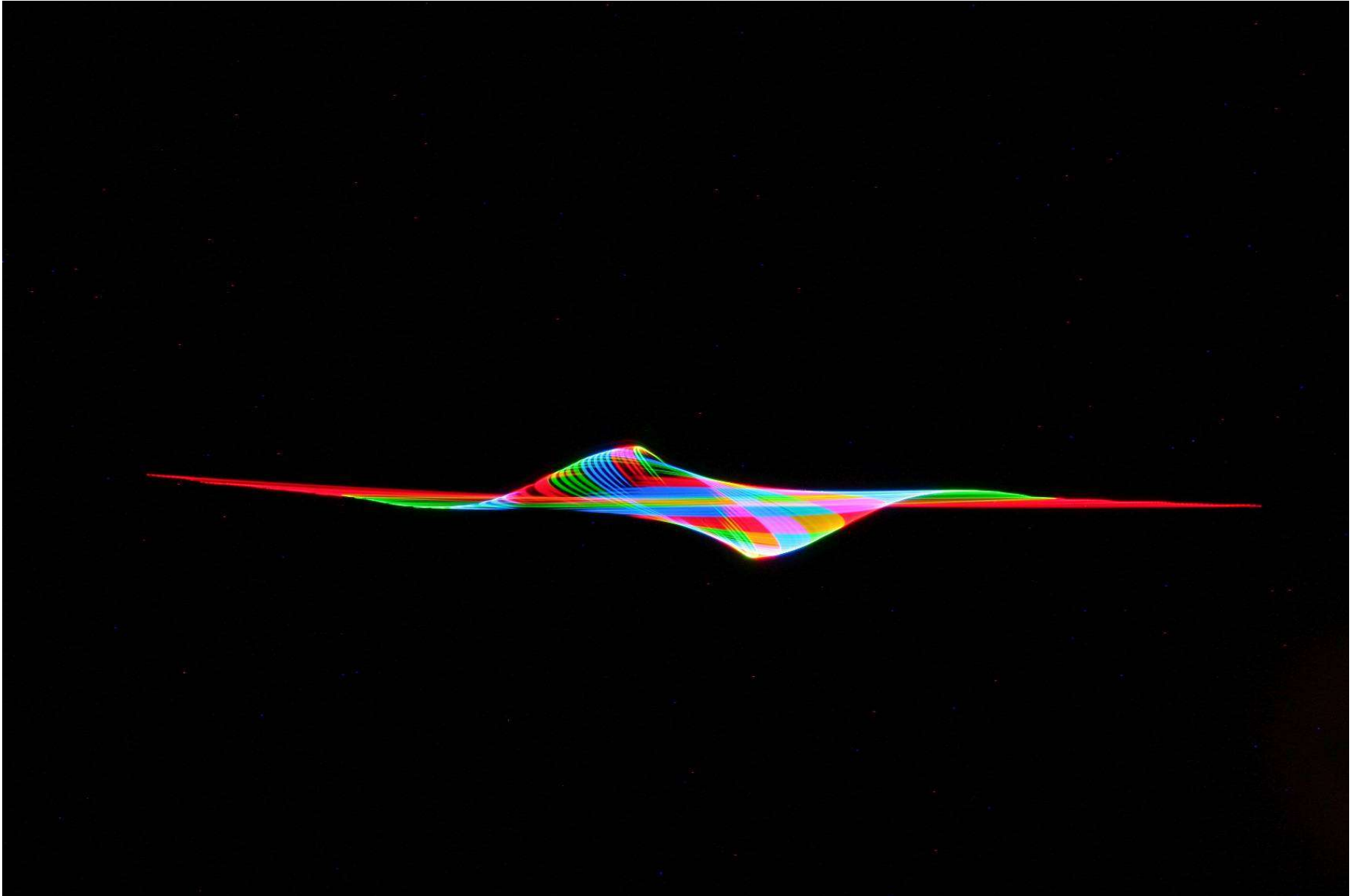
průměr φ za 15 min

$$\bar{\varphi} = 3^{\circ} 44' 17''$$

$$T = 18 \text{ h } 28 \text{ min}$$

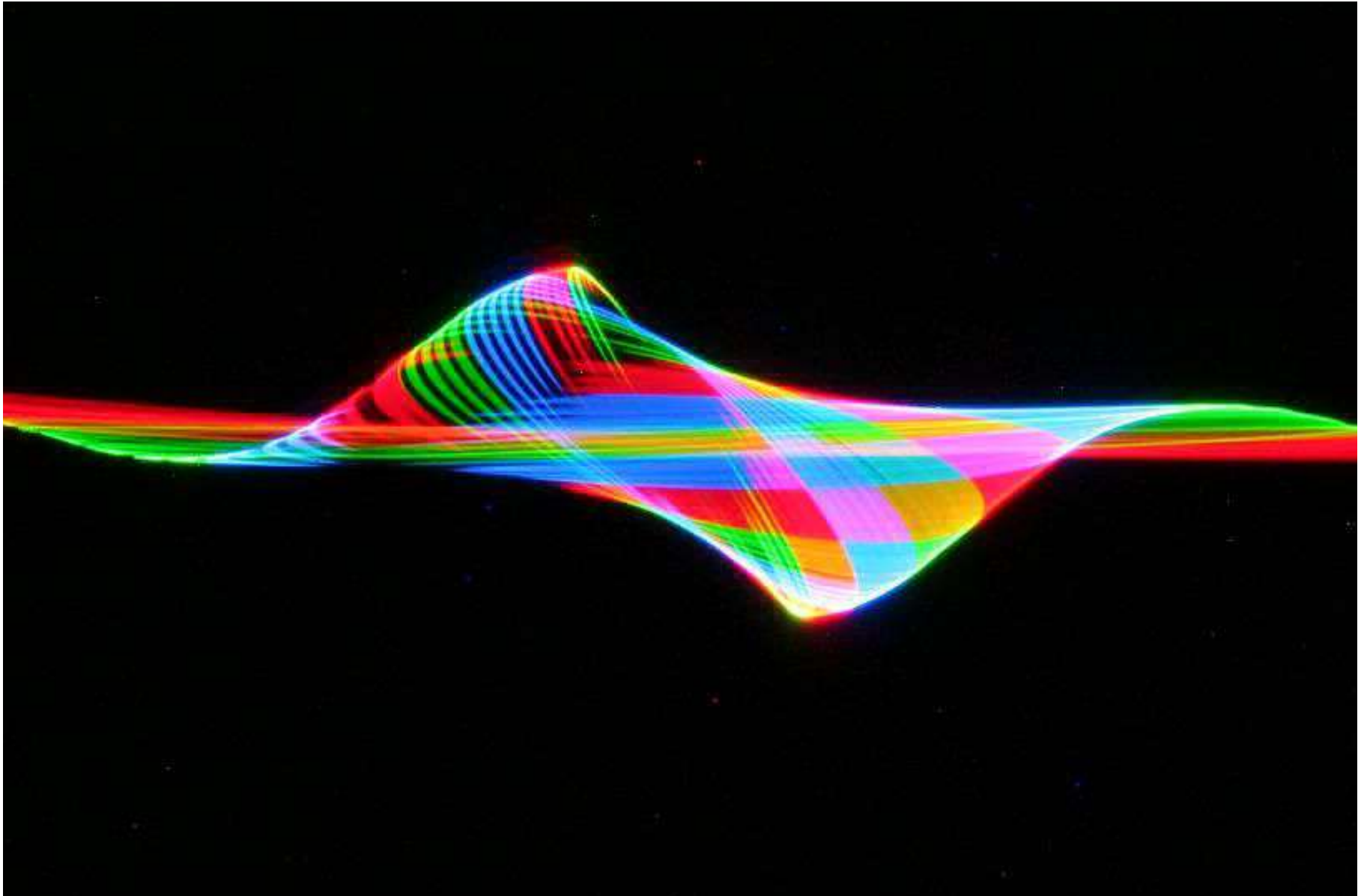
Postup

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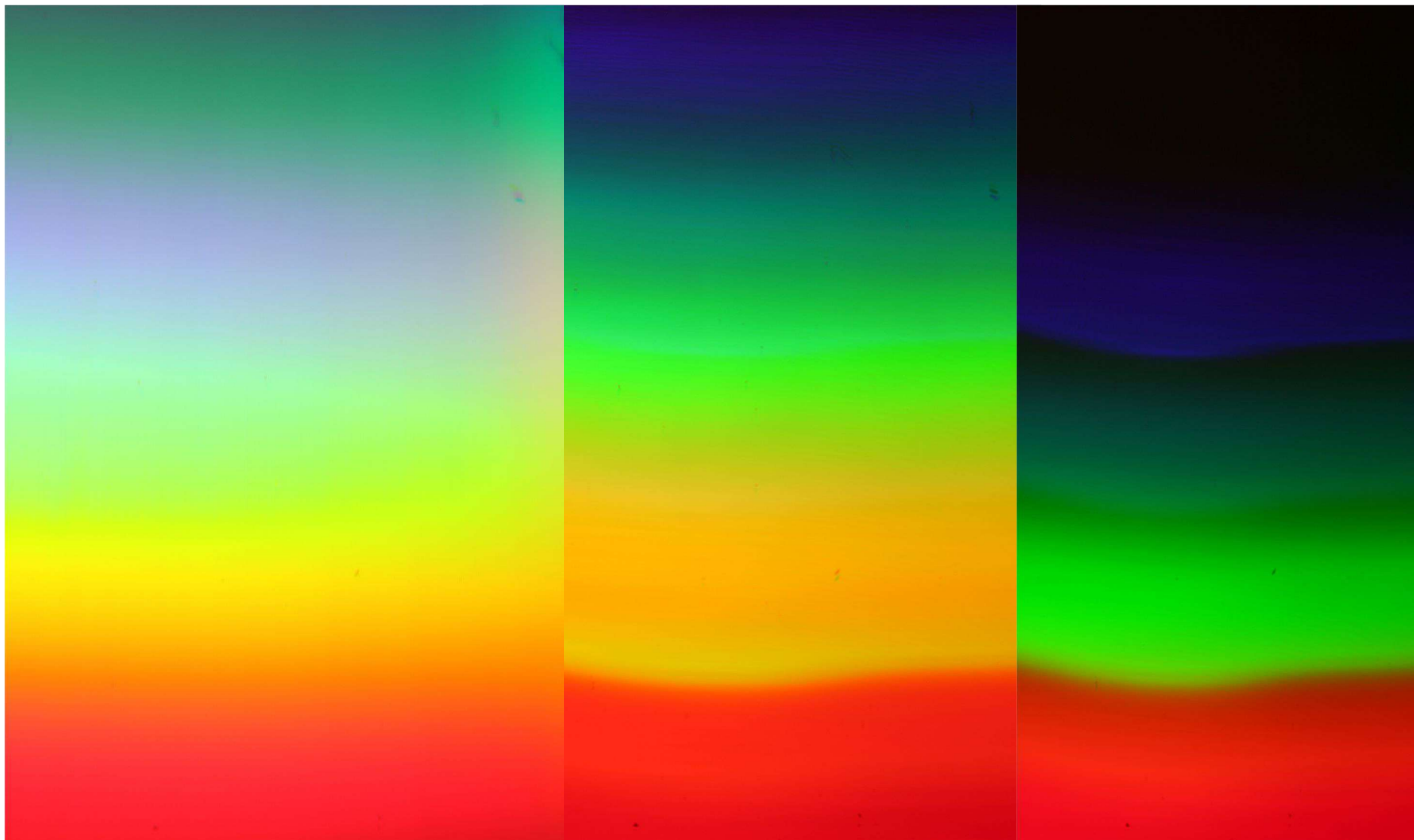


Postup

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Dodatek - Spektroskop



Závěr

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[2] IDNES [online], [cit. 03-04-2018], dostupné z:
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[3] Informační tabulka u Foucaultova kyvadla, Fakulta strojní ČVUT, Karlovo náměstí

[4] Transit finder [online], [cit. 04-04-2018], dostupné z:
<https://transit-finder.com>