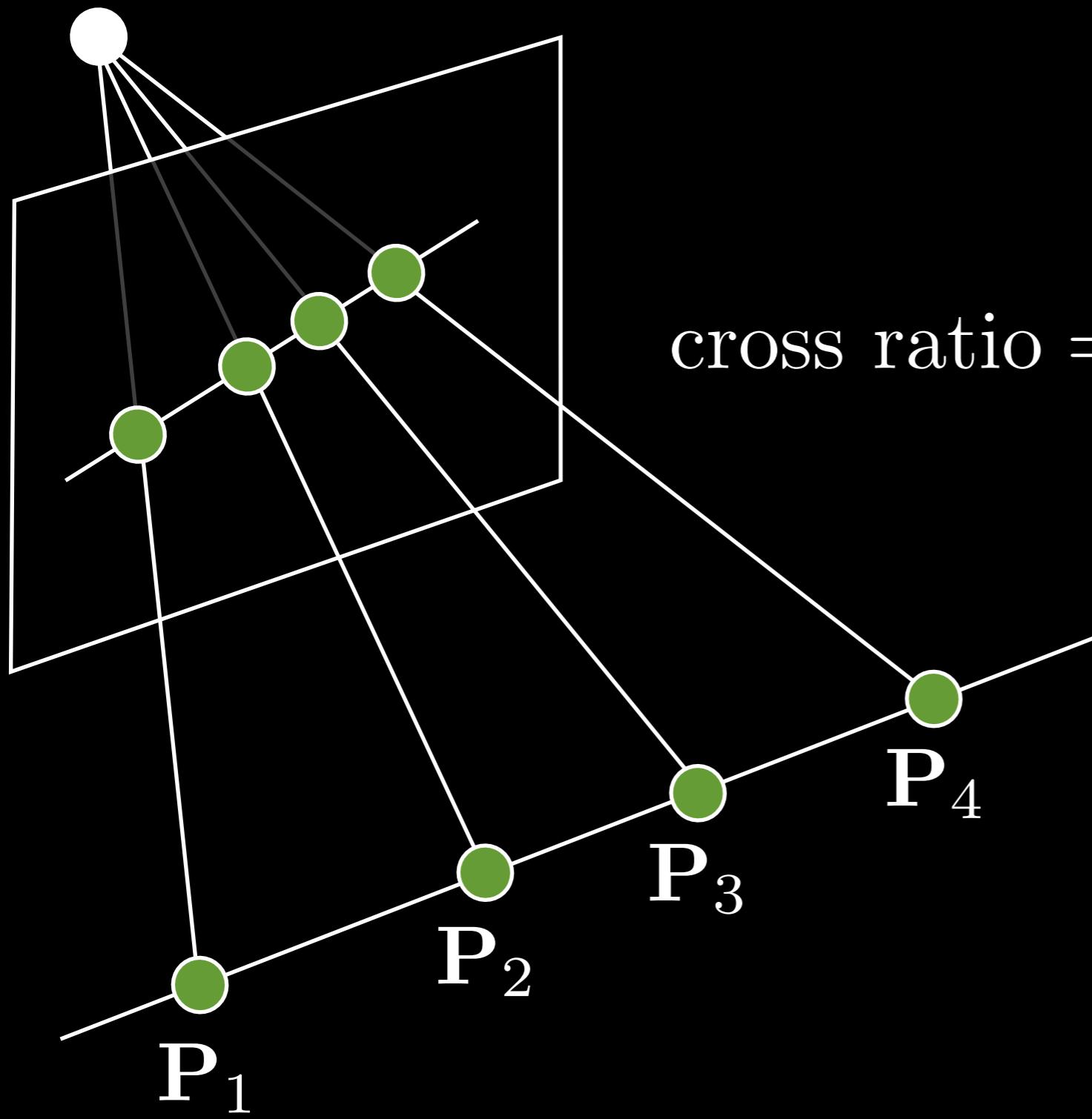


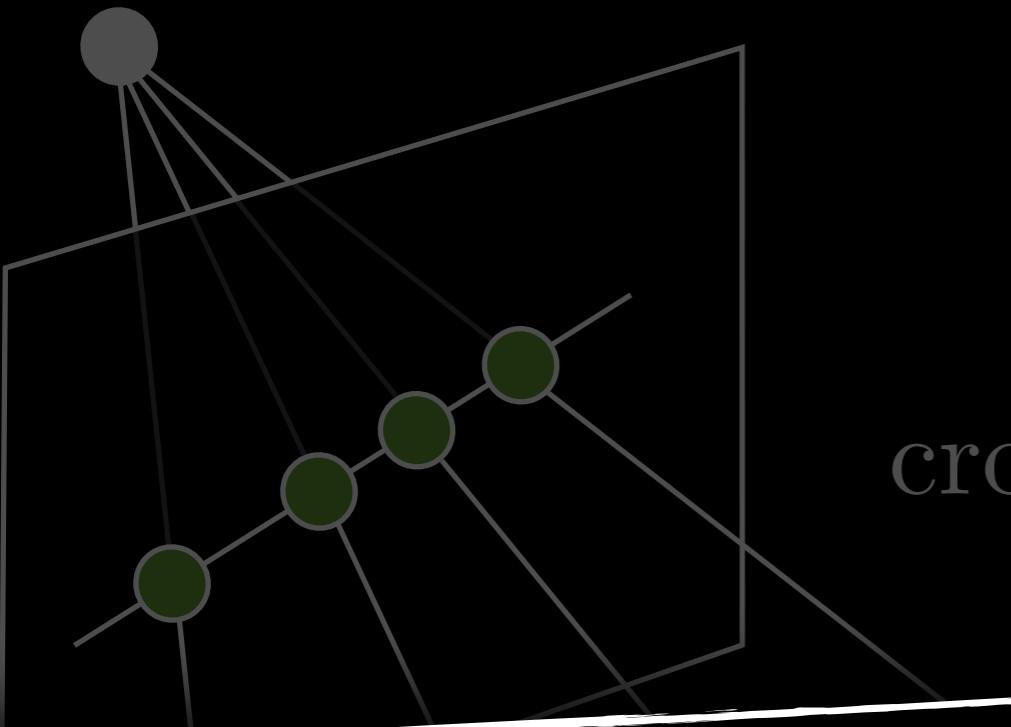
metrology
the science of measurement

cross ratio



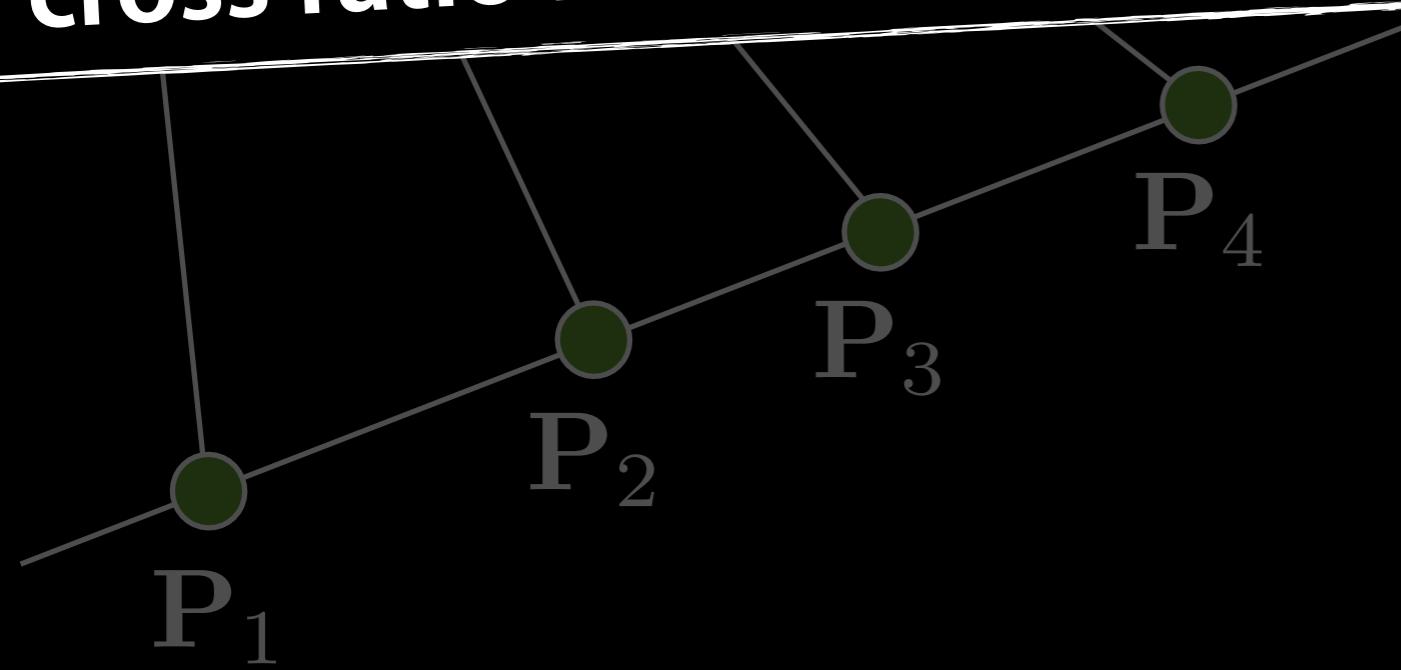
$$\text{cross ratio} = \frac{\|P_3 - P_1\| \|P_4 - P_2\|}{\|P_3 - P_2\| \|P_4 - P_1\|}$$

cross ratio

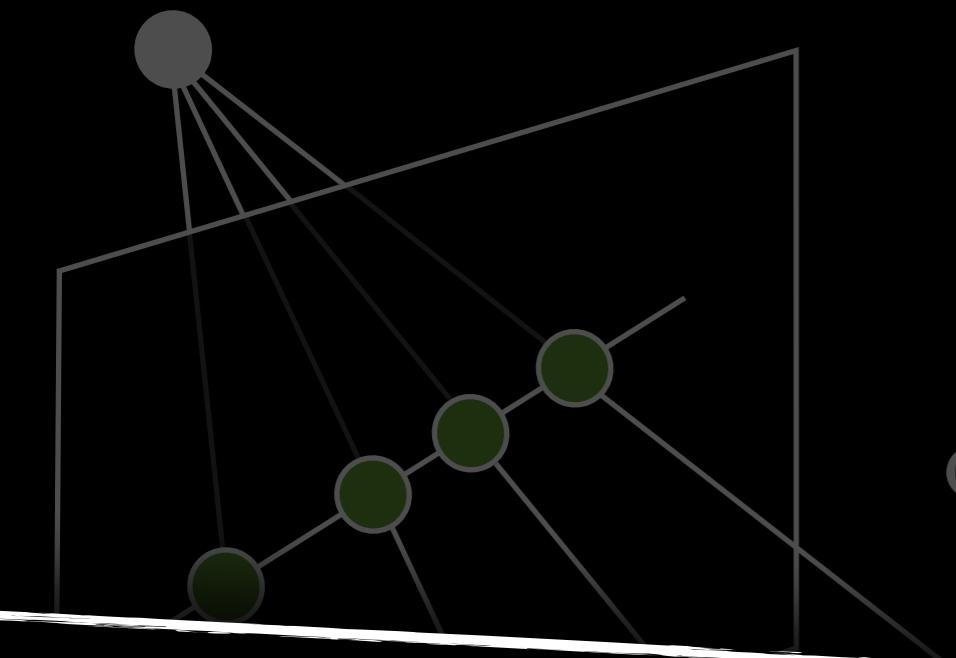


$$\text{cross ratio} = \frac{\|P_3 - P_1\| \|P_4 - P_2\|}{\|P_3 - P_2\| \|P_4 - P_1\|}$$

cross ratio is invariant under perspective projection

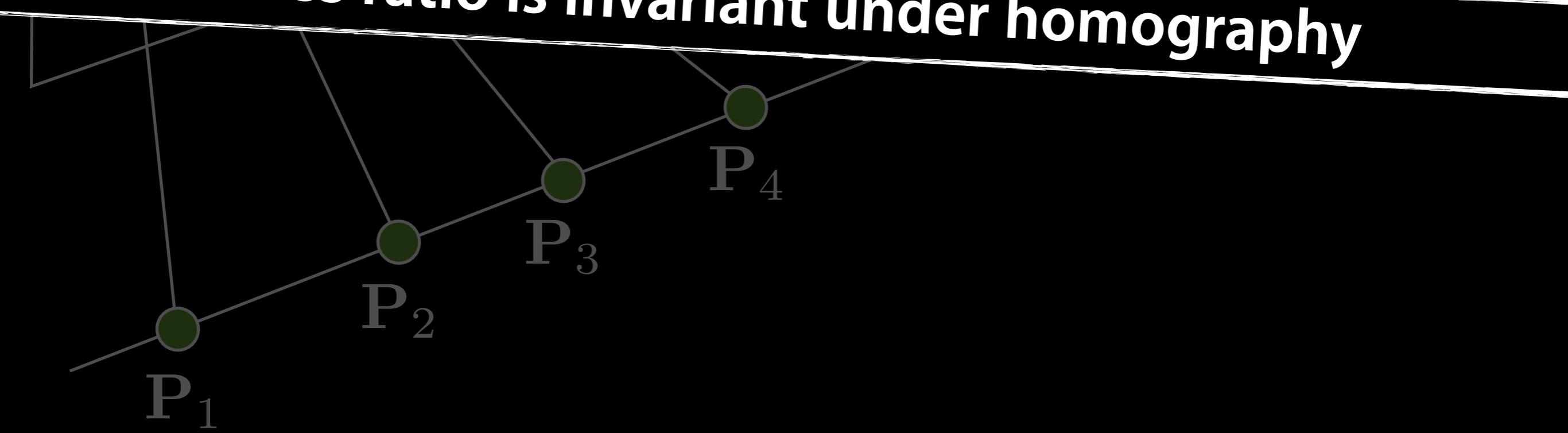


cross ratio

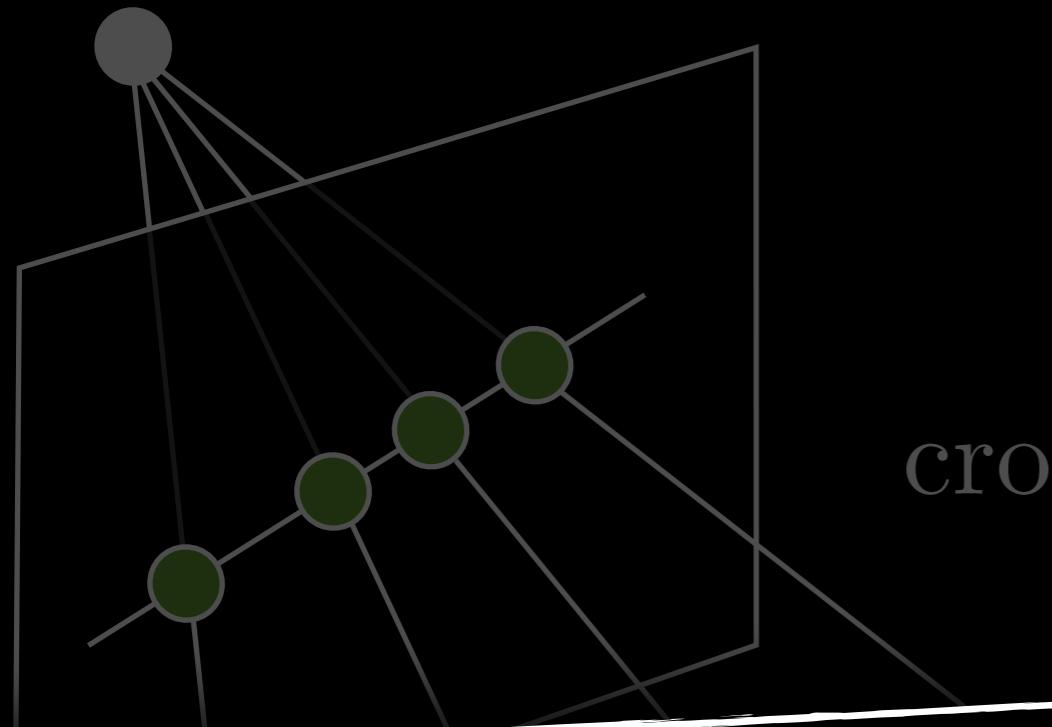


$$\text{cross ratio} = \frac{\|P_3 - P_1\| \|P_4 - P_2\|}{\|P_3 - P_2\| \|P_4 - P_1\|}$$

cross ratio is invariant under homography

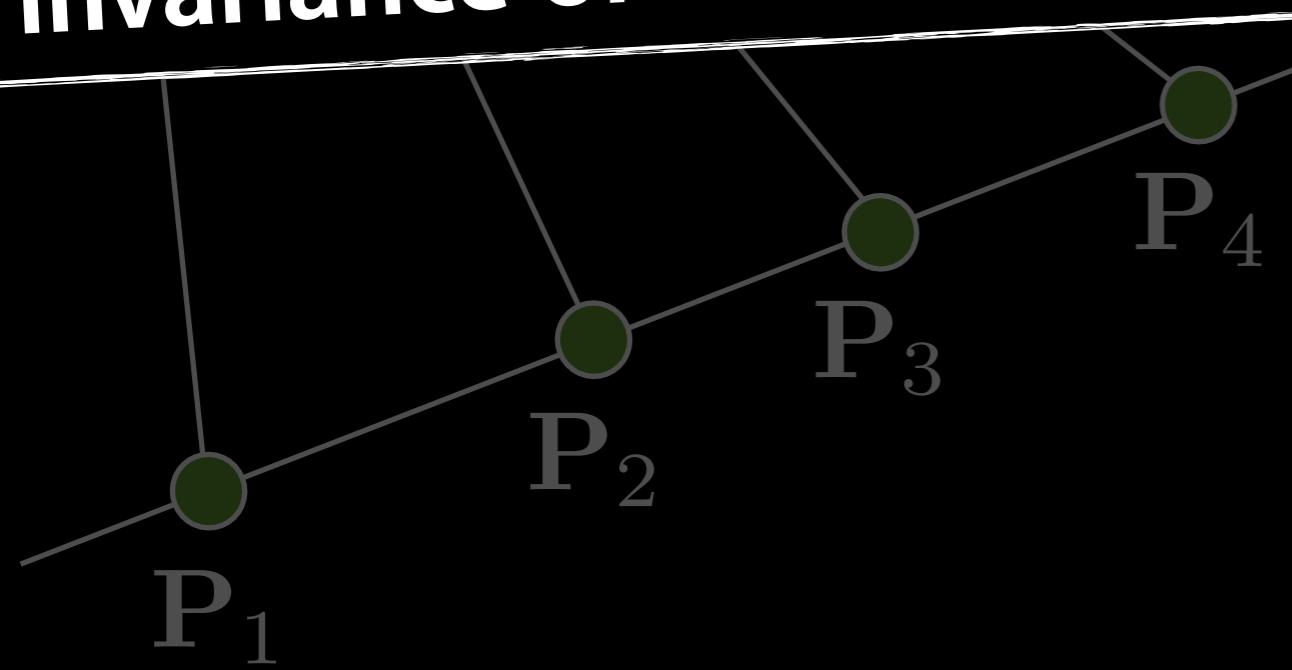


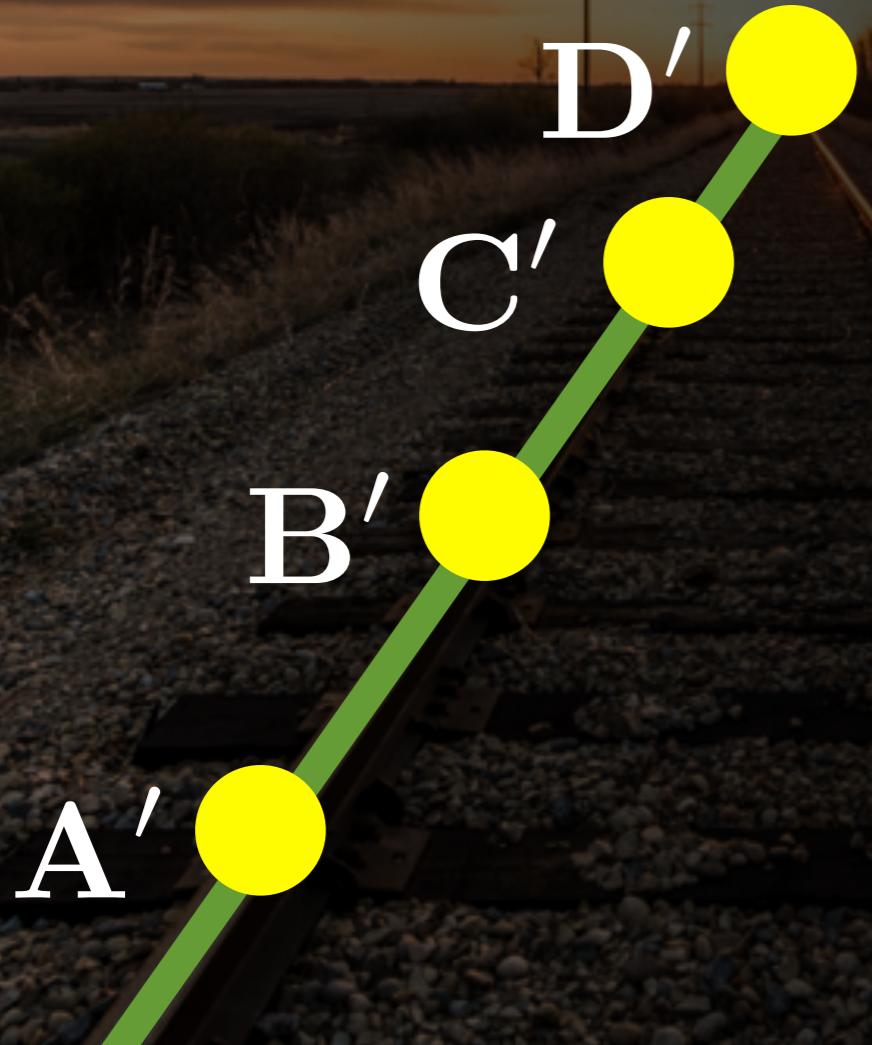
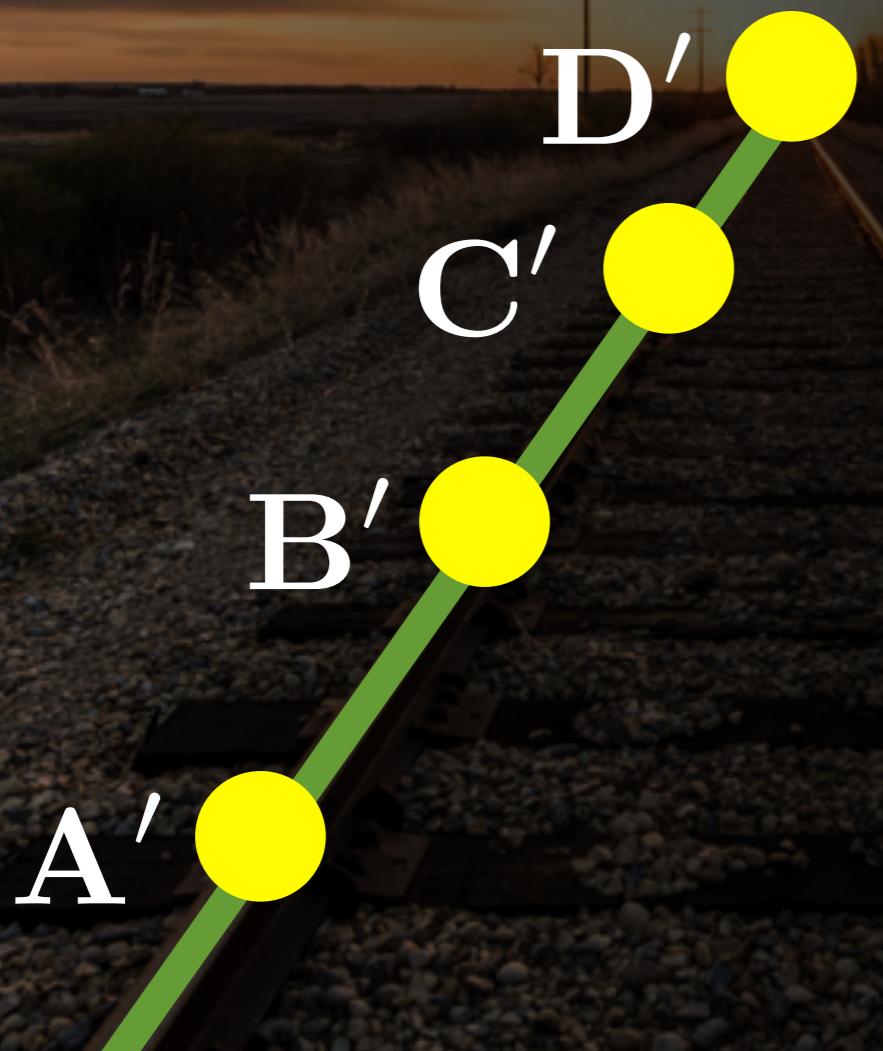
cross ratio



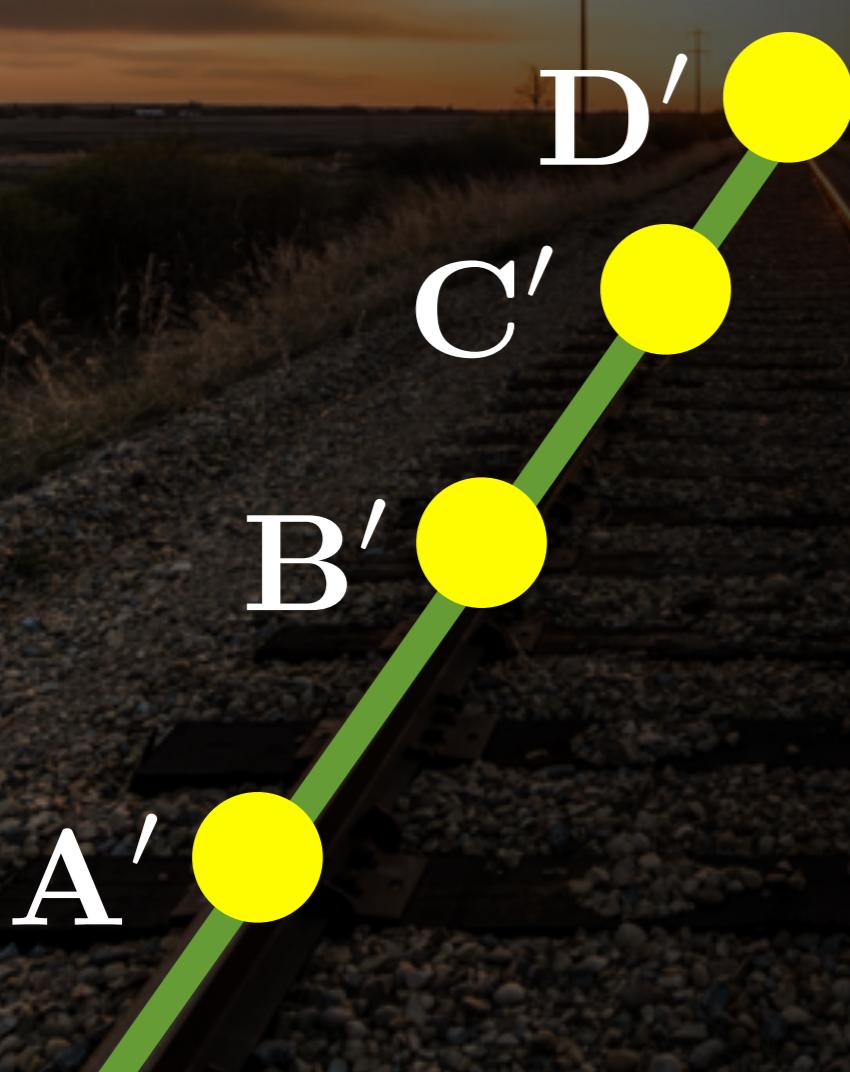
$$\text{cross ratio} = \frac{\|P_3 - P_1\| \|P_4 - P_2\|}{\|P_3 - P_2\| \|P_4 - P_1\|}$$

invariance of cross ratio remains under permutation





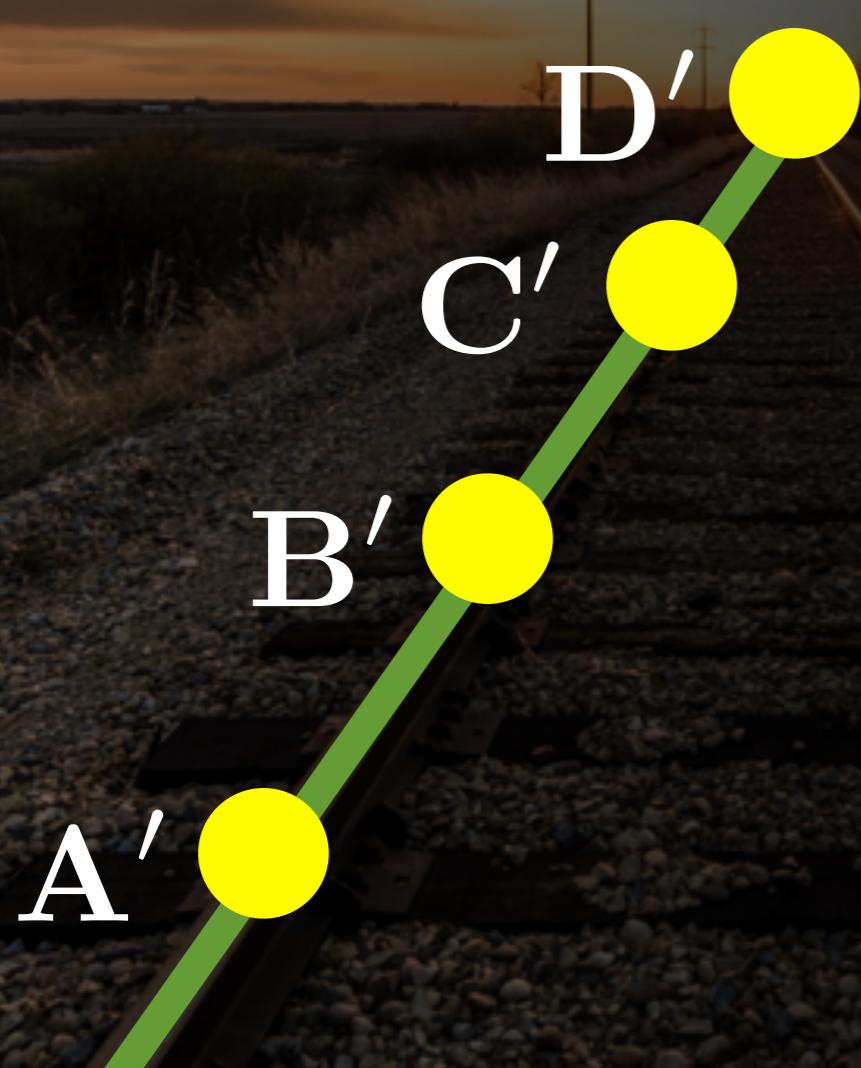
$$\frac{A'C'}{A'D'} : \frac{B'C'}{B'D'} = \frac{AC}{AD} : \frac{BC}{BD}$$
$$= \frac{AC}{BC} : \frac{\cancel{AD}}{\cancel{BD}}$$
$$= \frac{AC}{BC}$$



~~$\frac{AD}{BD}$~~

1

$$\frac{A'C'}{A'D'} : \frac{B'C'}{B'D'} = \frac{AC}{BC}$$

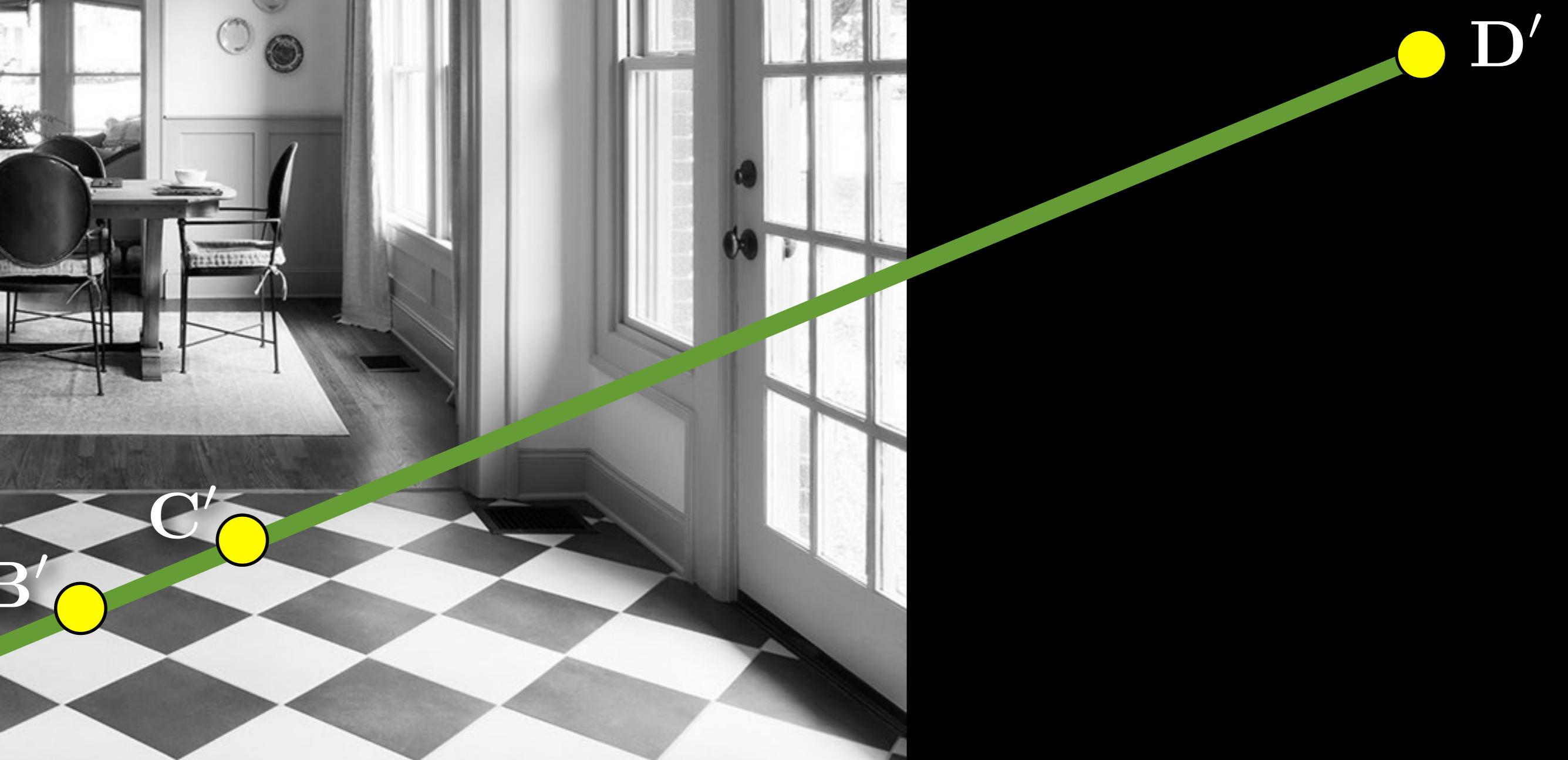


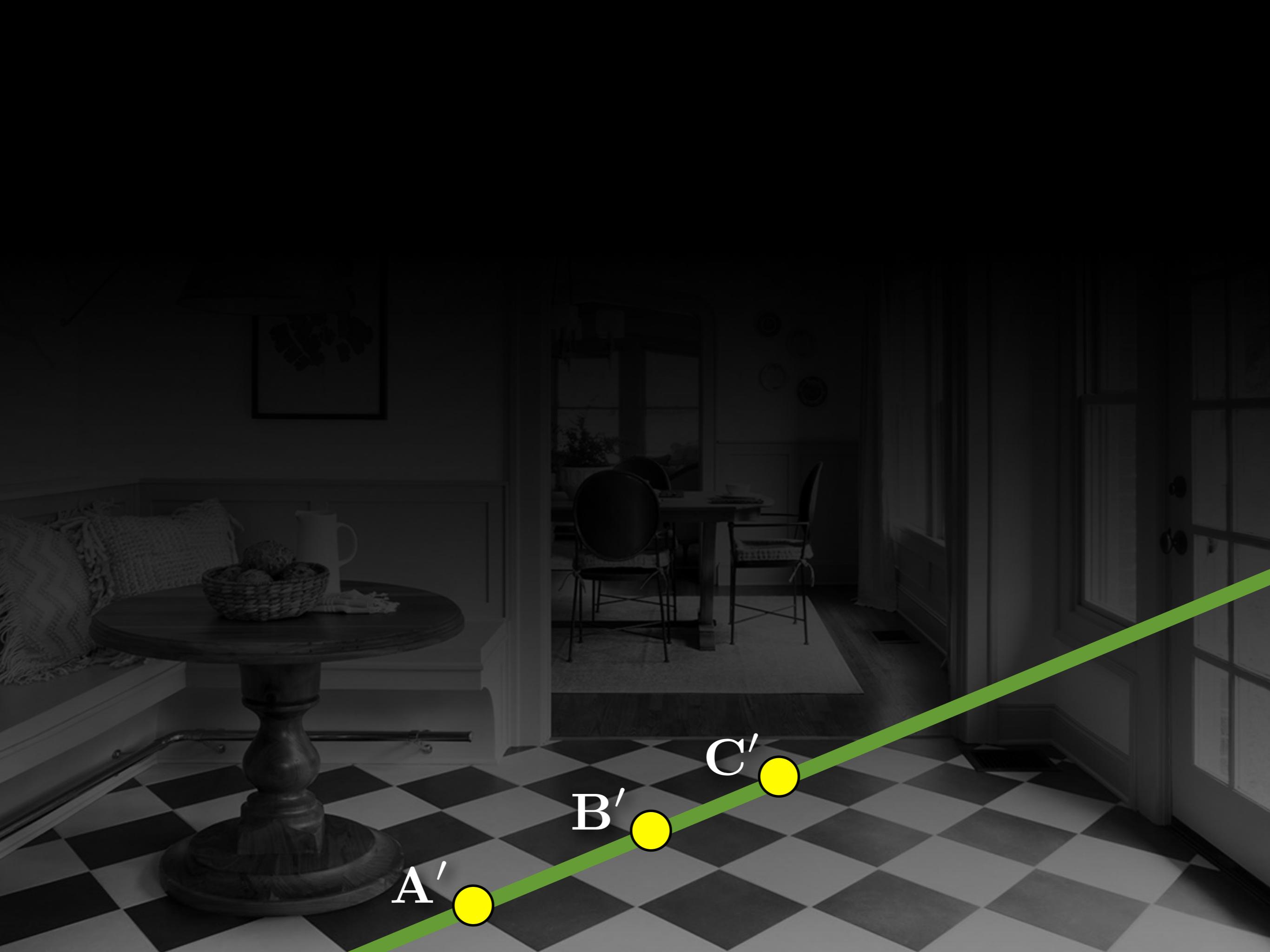


A'

B'

C'

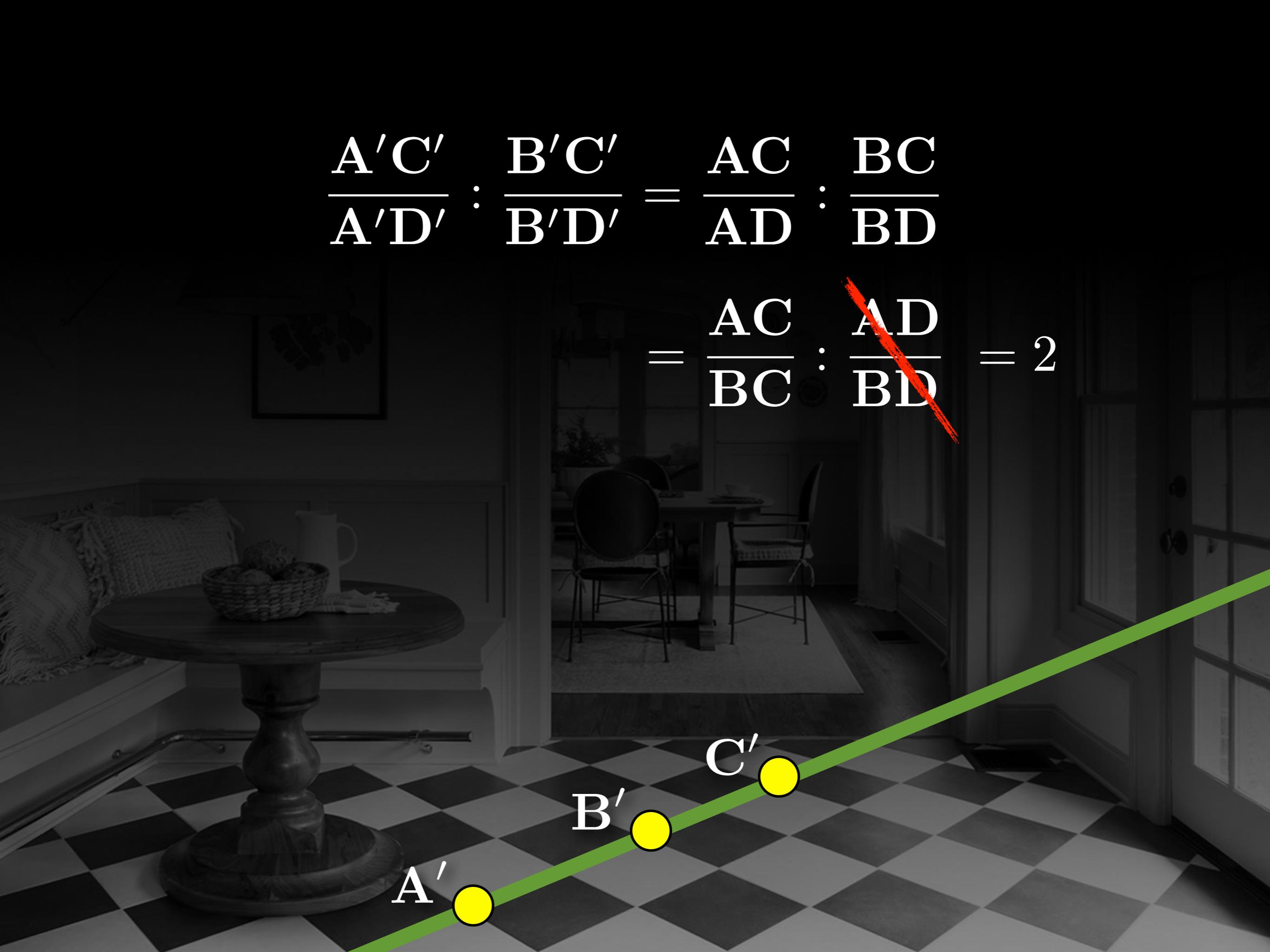




A'
B'
C'

$$\frac{A'C'}{A'D'} : \frac{B'C'}{B'D'} = \frac{AC}{AD} : \frac{BC}{BD}$$

$$= \frac{AC}{BC} : \frac{\cancel{AD}}{\cancel{BD}} = 2$$

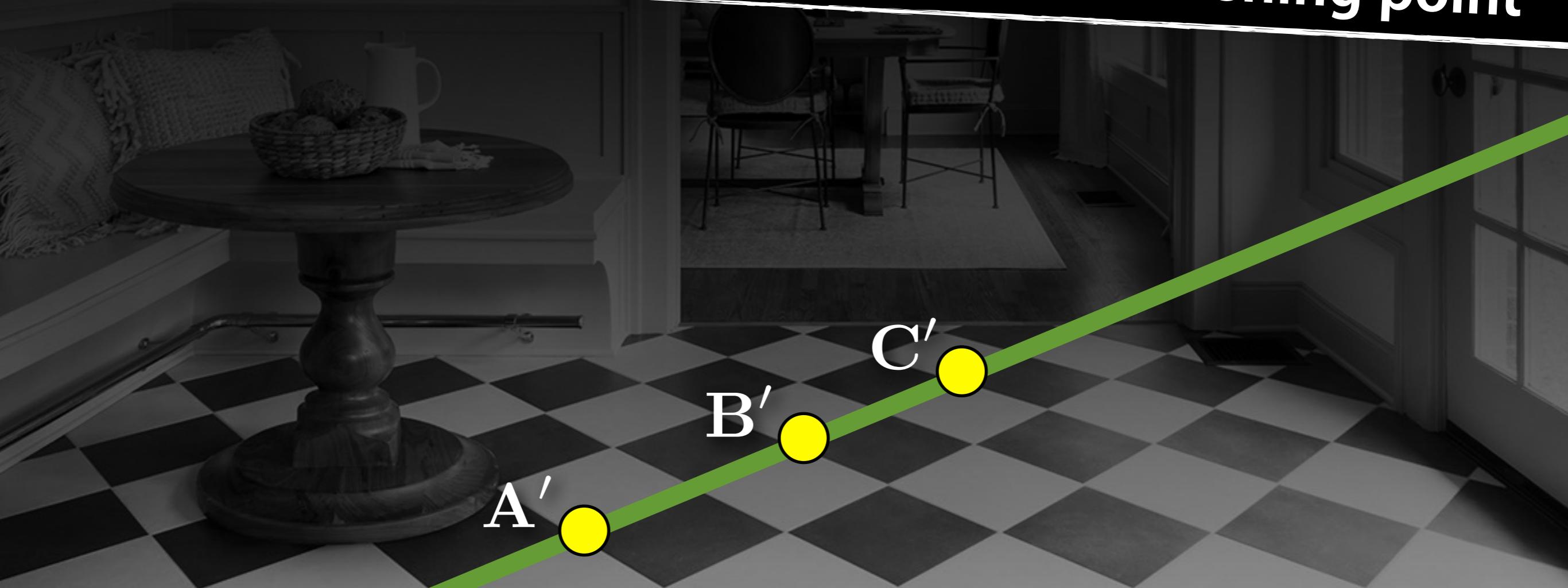


A' B' C'

$$\frac{A'C'}{A'D'} : \frac{B'C'}{B'D'} = \frac{AC}{AD} : \frac{BC}{BD}$$

$$= \frac{AC}{BC} : \frac{\cancel{AD}}{\cancel{BD}} = 2$$

given the corners in pixels, can recover vanishing point



 A' B' C'

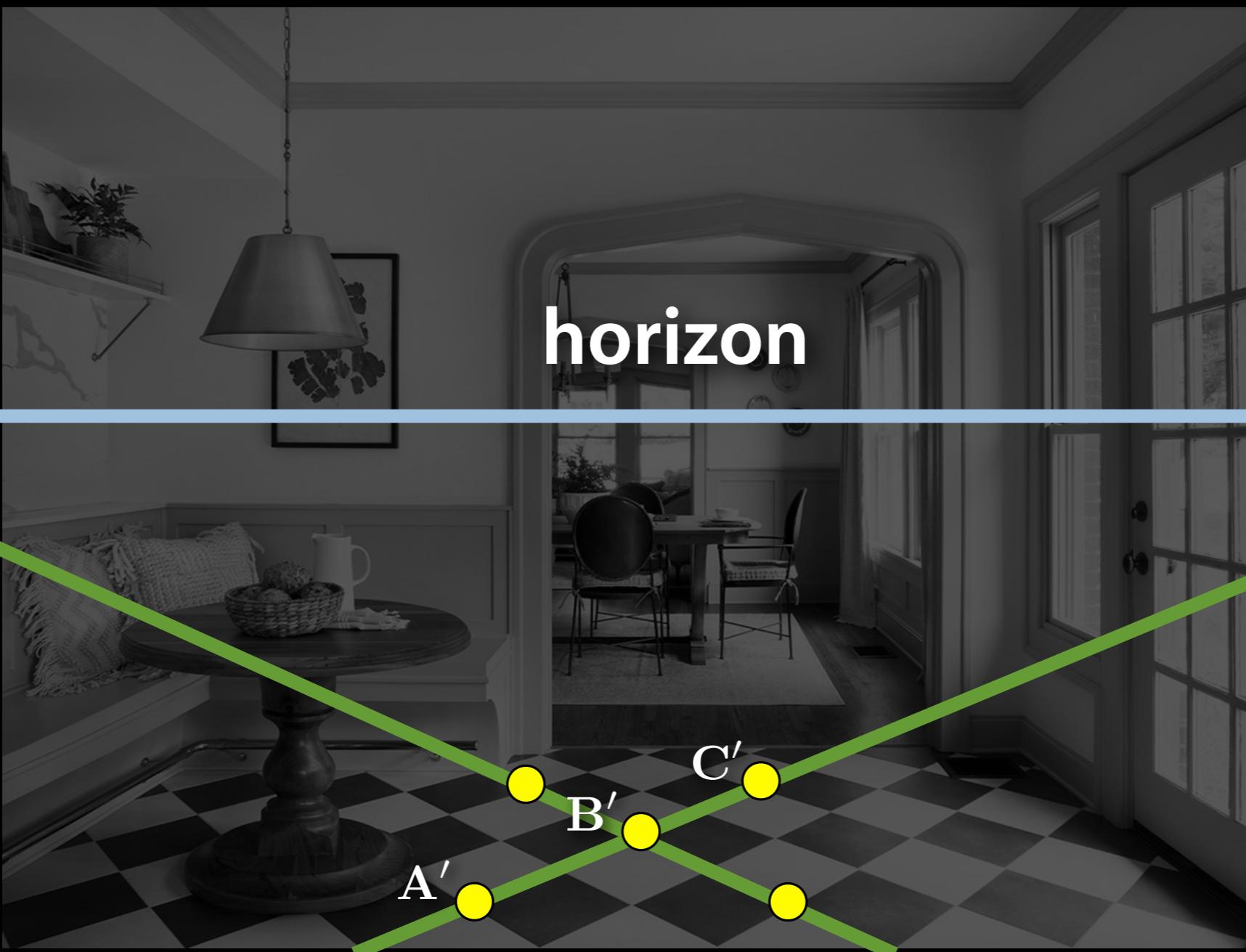


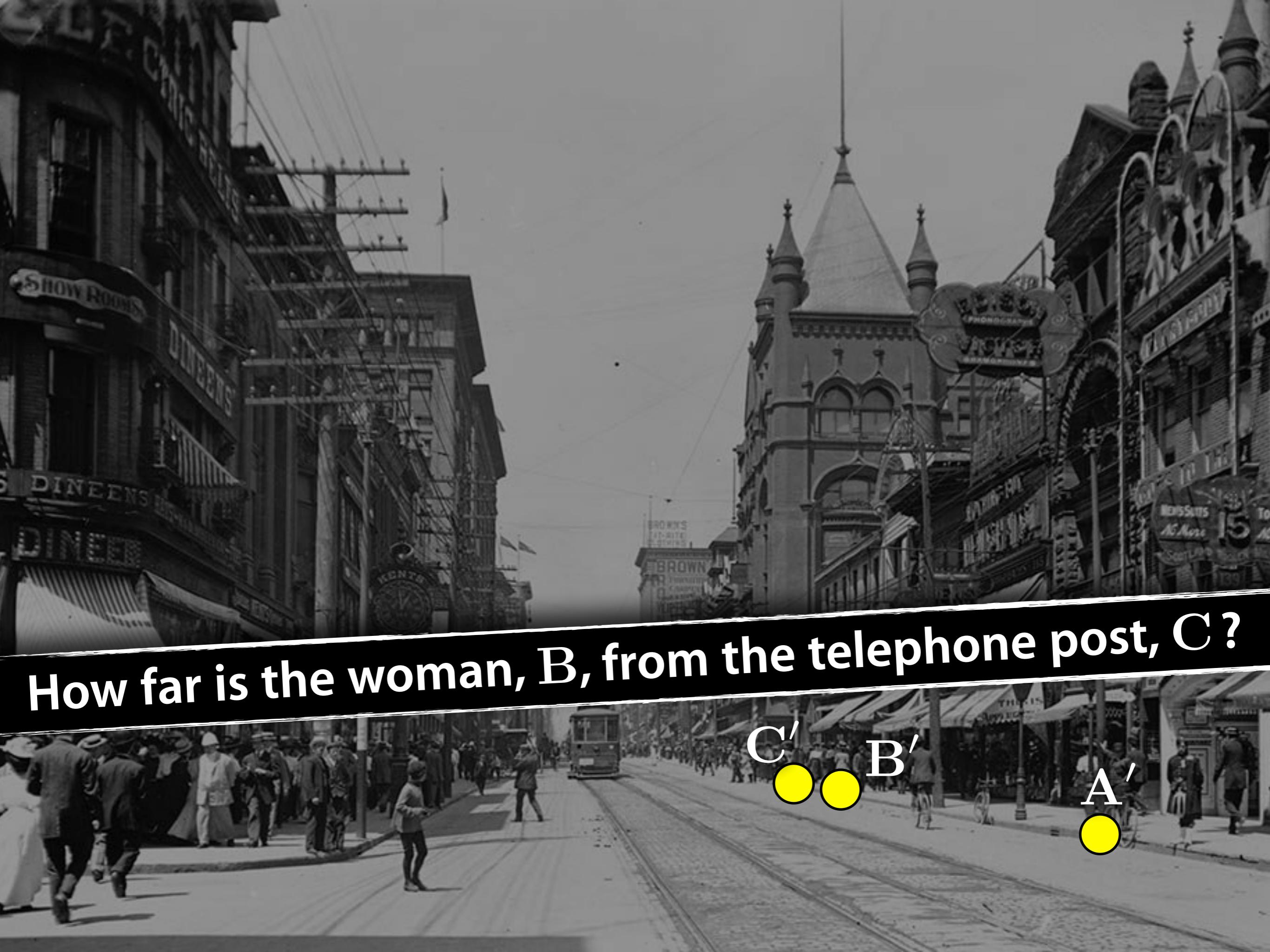
A'

B'

C'







How far is the woman, B, from the telephone post, C?







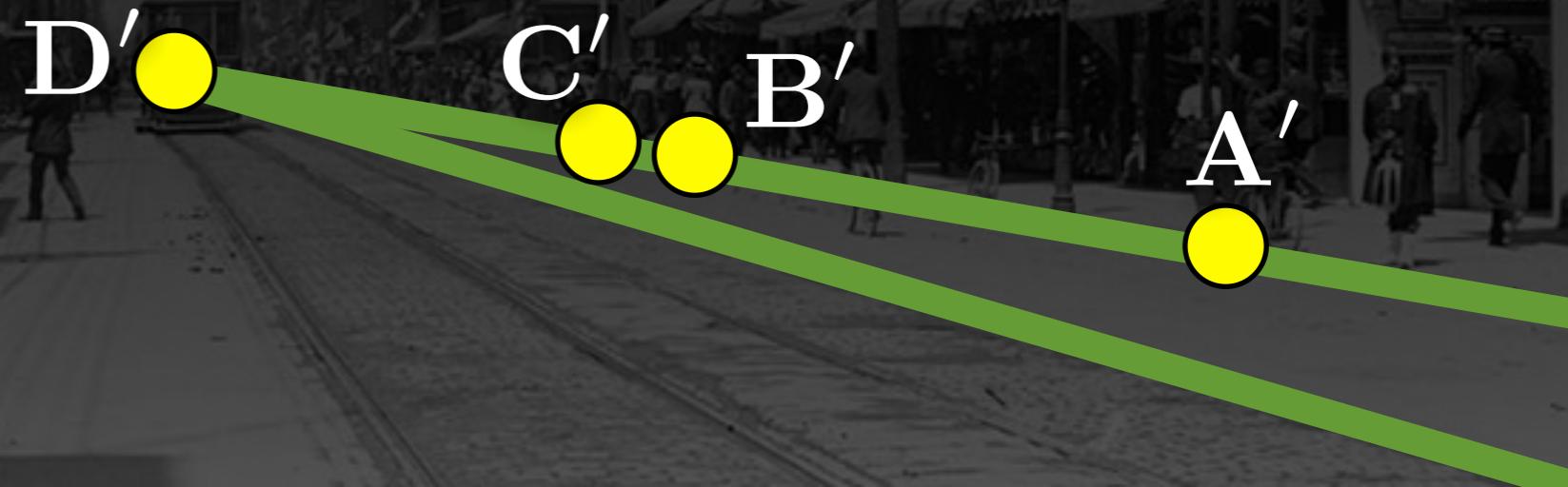
D'

C'

B'

A'

$$\frac{A'C'}{A'D'} : \frac{B'C'}{B'D'} = \frac{AC}{BC}$$

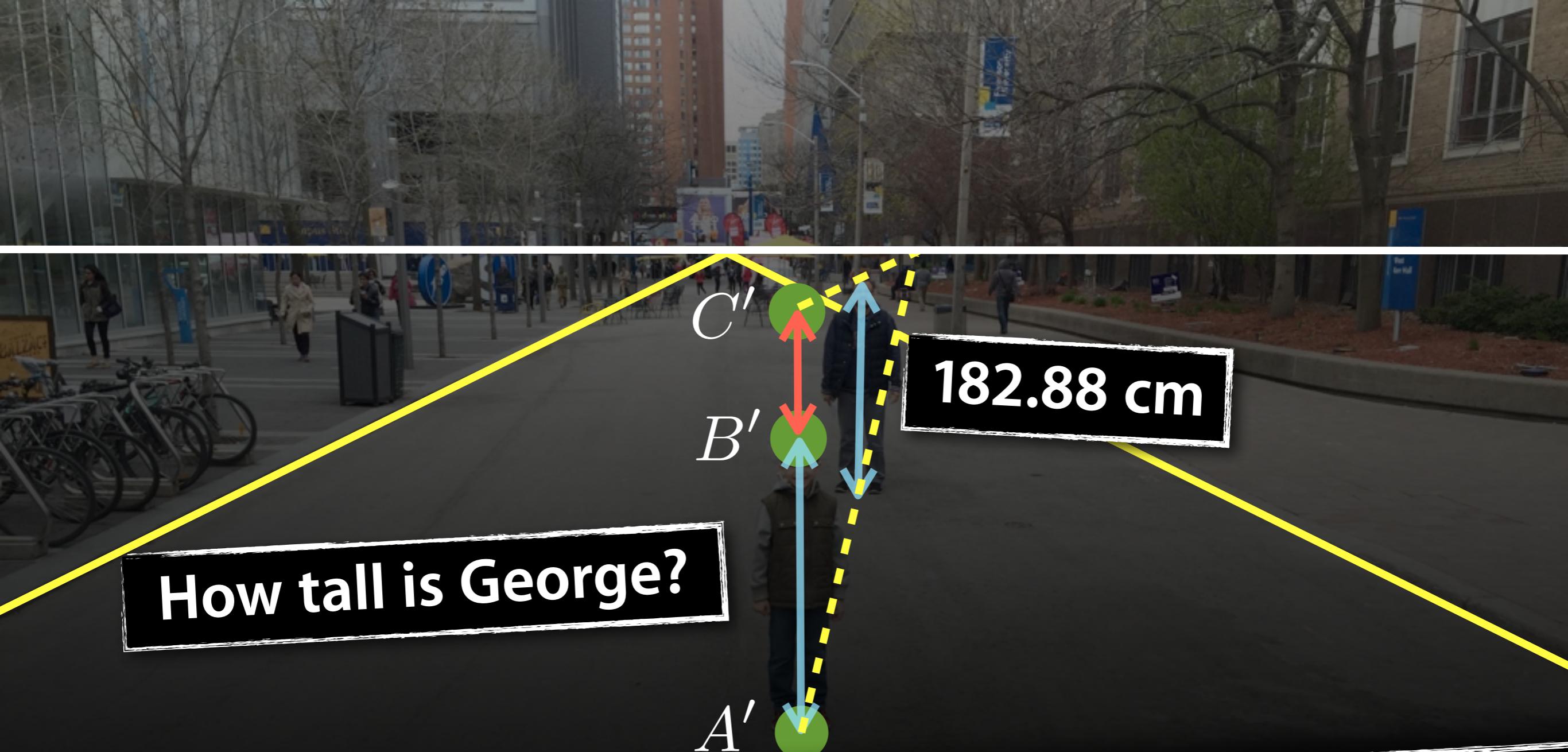


$$\frac{A'C'}{A'D'} : \frac{B'C'}{B'D'} = \frac{AC}{BC}$$

Given the lamp posts are 25 meters apart and
the image points (in pixels)

$$BC = \frac{(AC)(A'D')(B'C')}{(A'C')(B'D')}$$

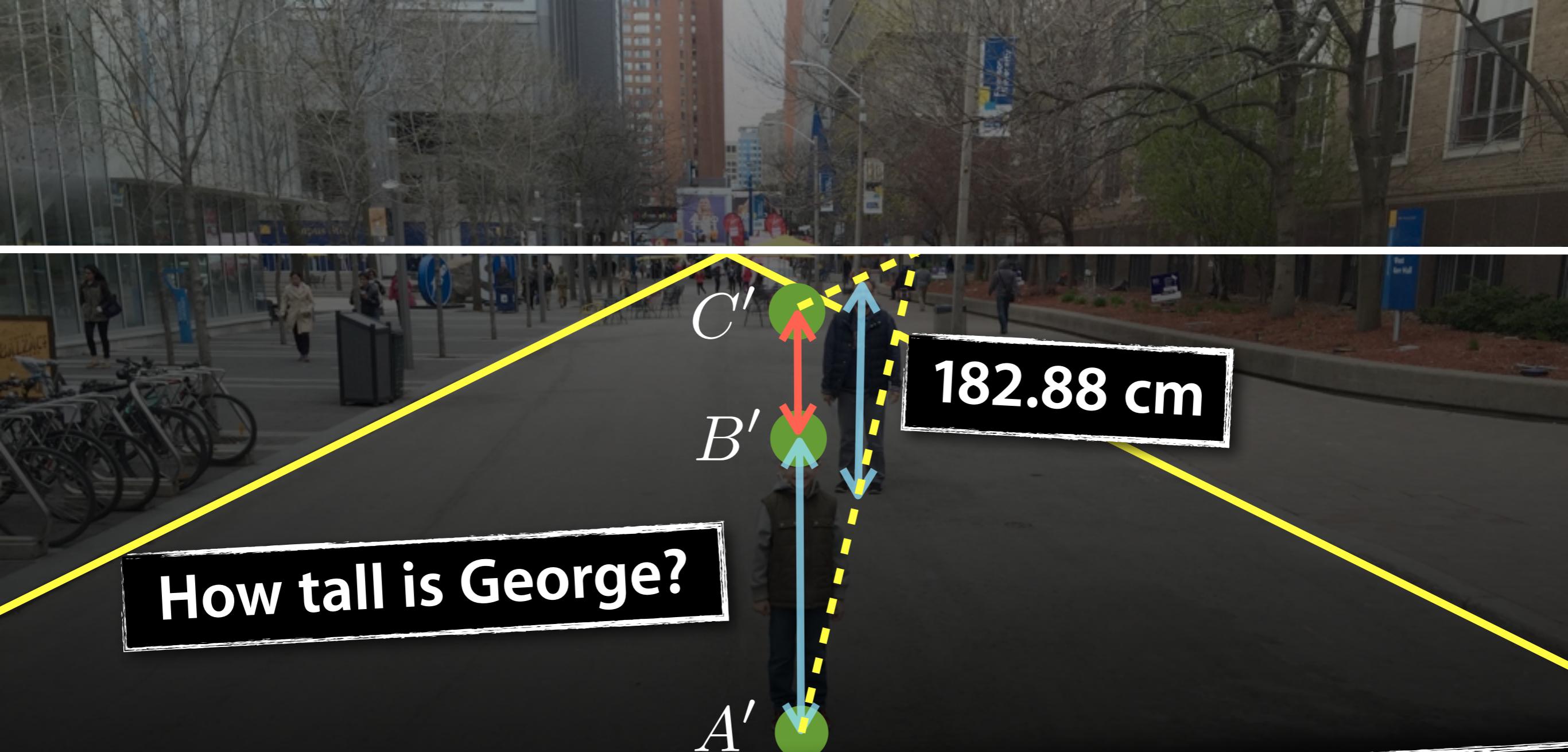




How tall is George?

182.88 cm

D' is the vertical vanishing point



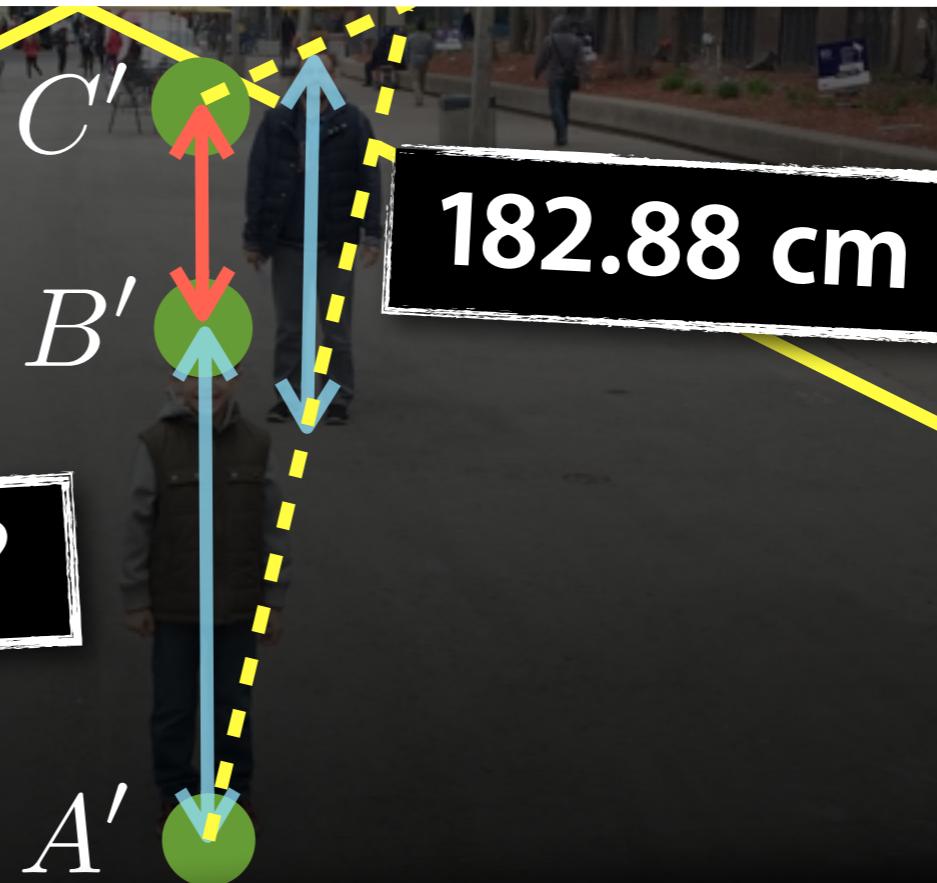
How tall is George?

182.88 cm

D' is the vertical vanishing point

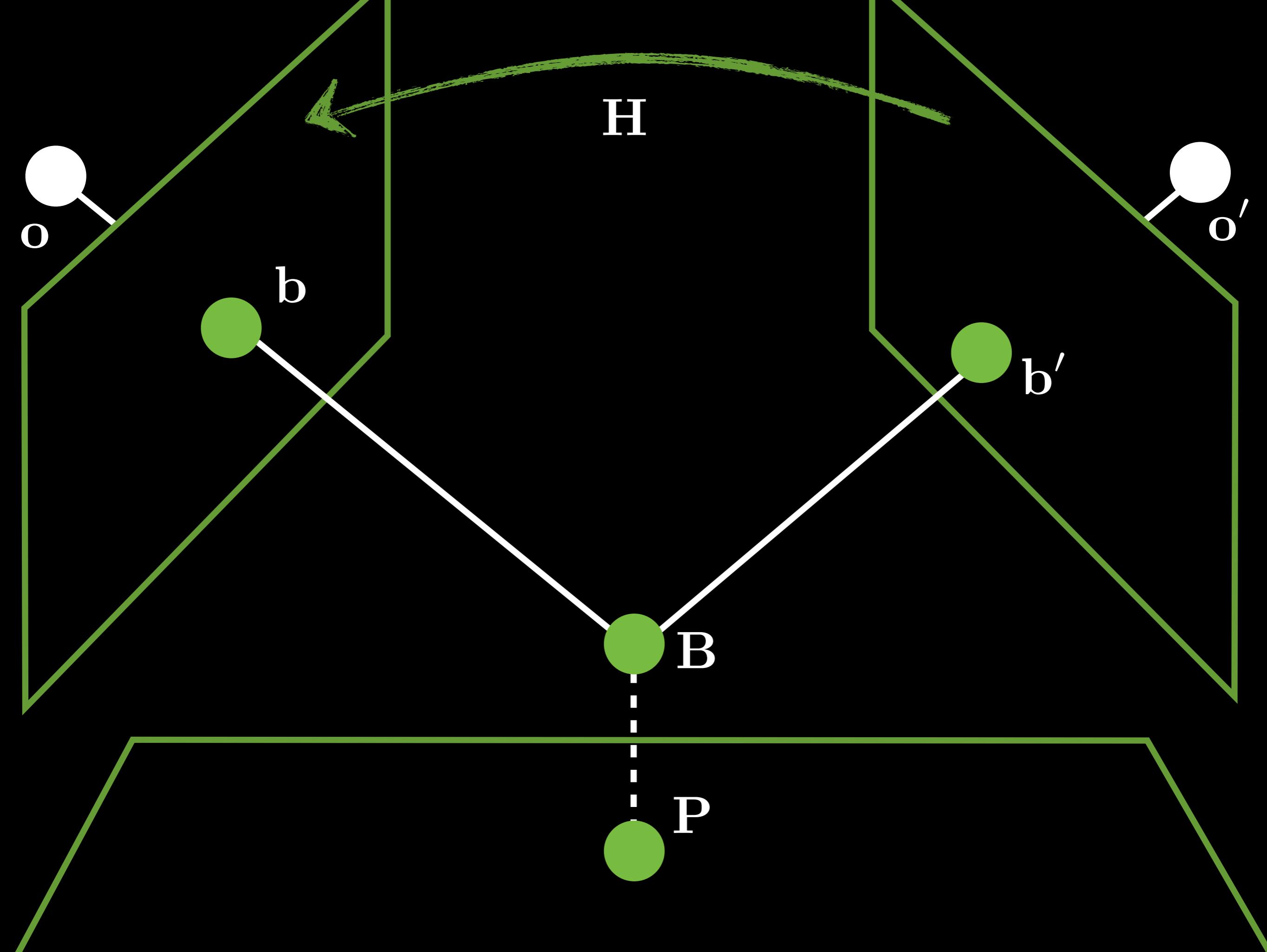
$$\frac{A'C'}{A'D'} : \frac{B'C'}{B'D'} = \frac{AC}{BC}$$

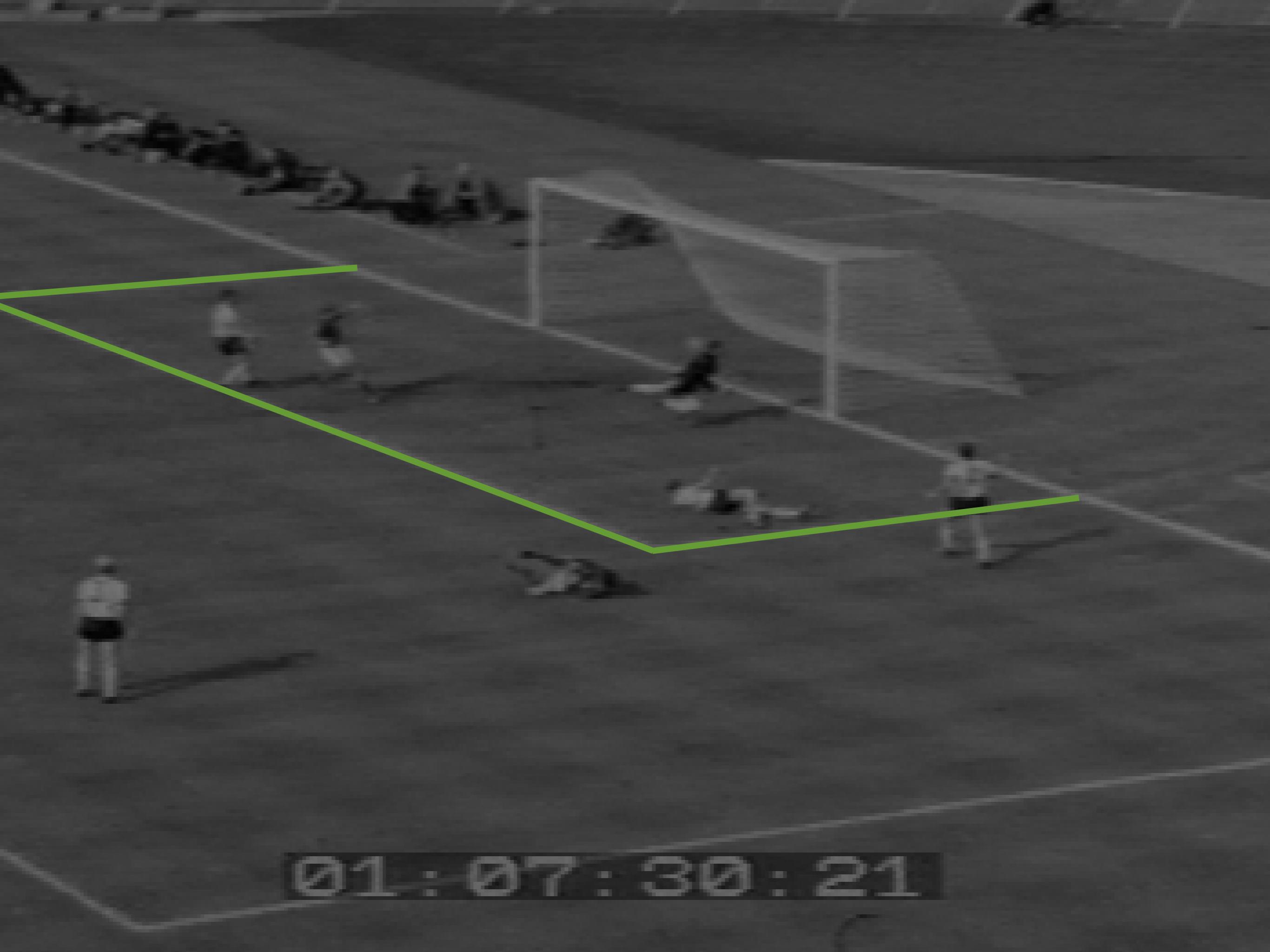
How tall is George?



$$\frac{A'C'}{A'D'} : \frac{B'C'}{B'D'} = \frac{AC}{BC}$$

To find AB, solve for BC and subtract from AC

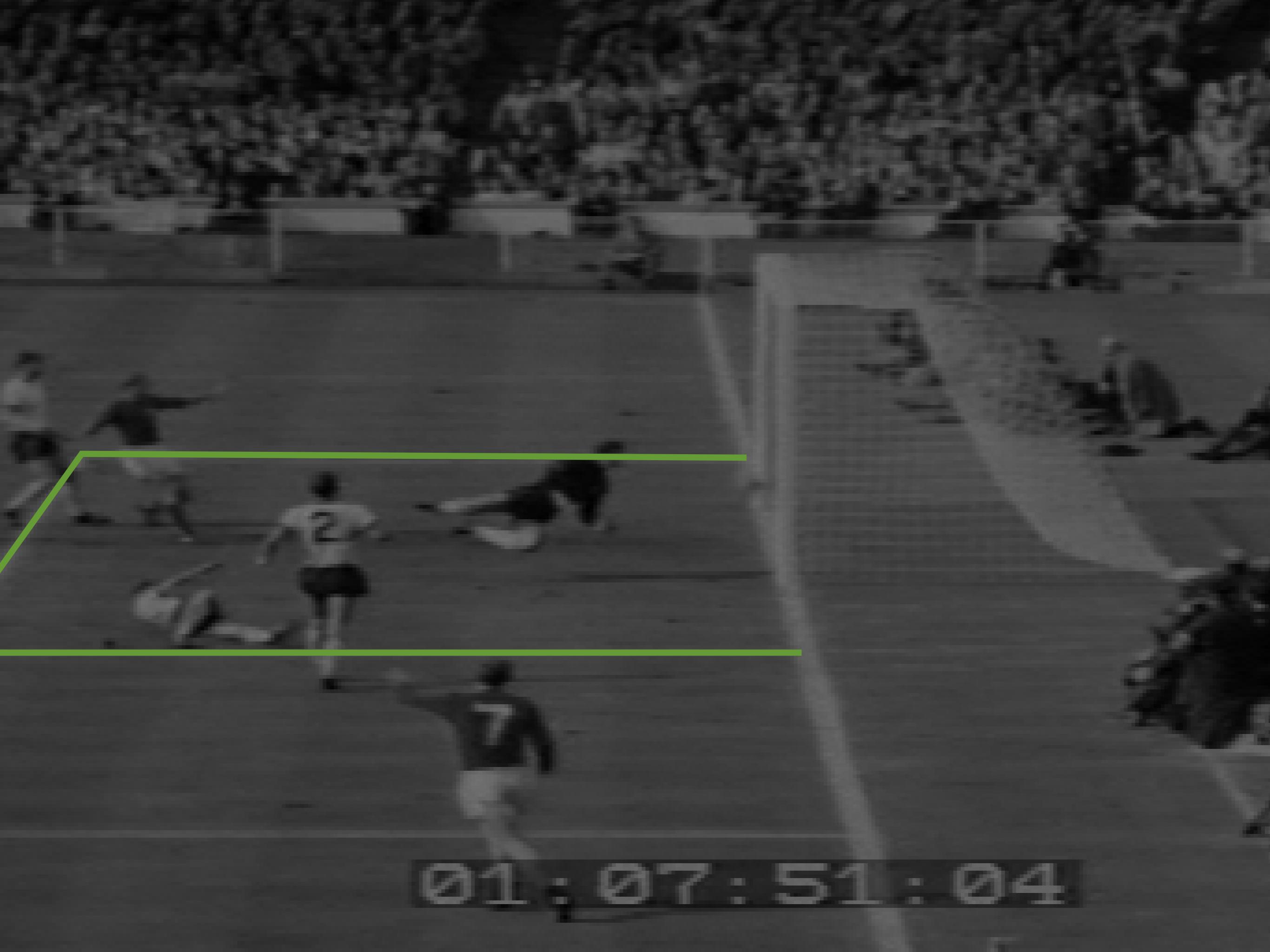




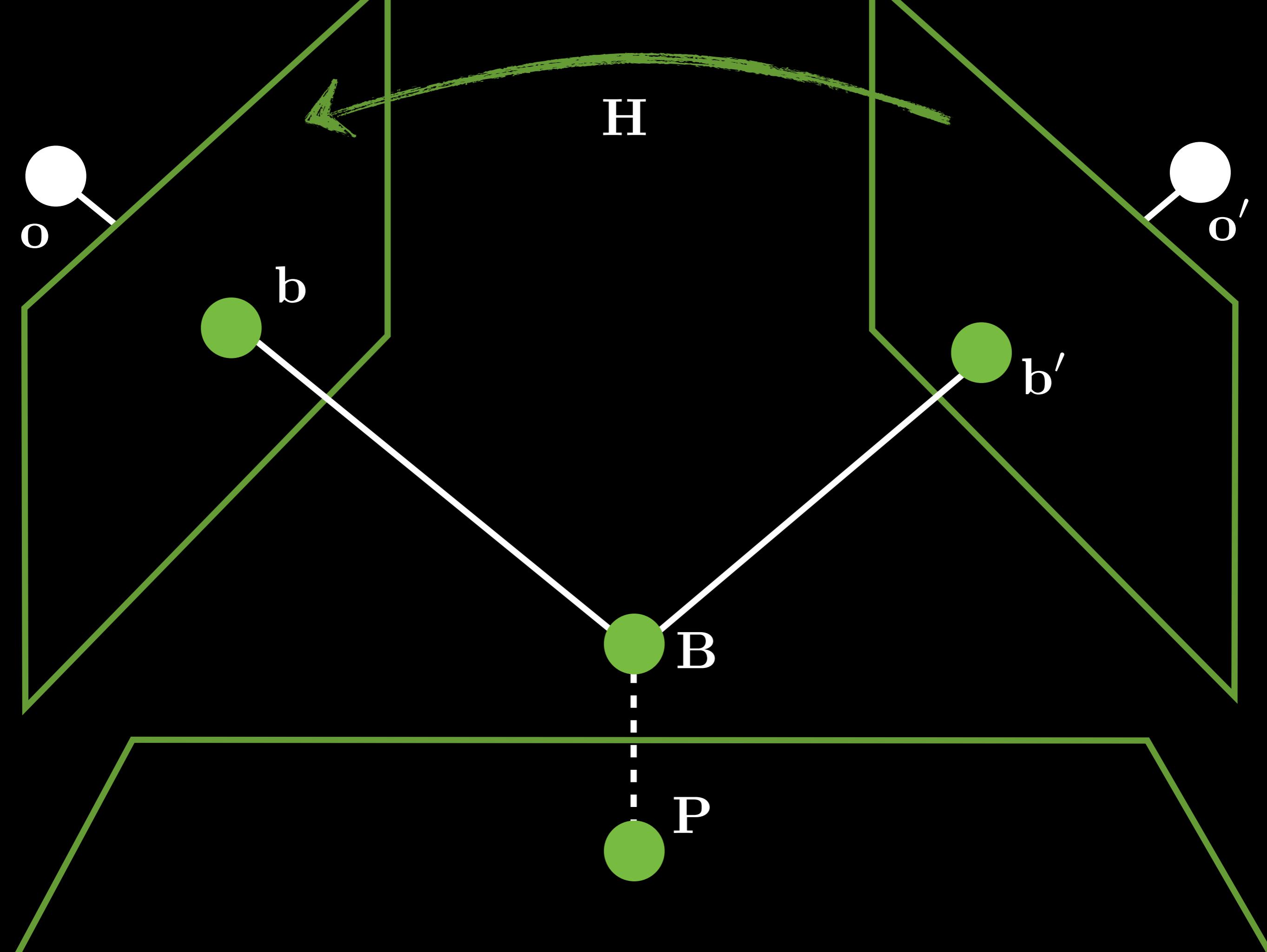
01:07:30:21

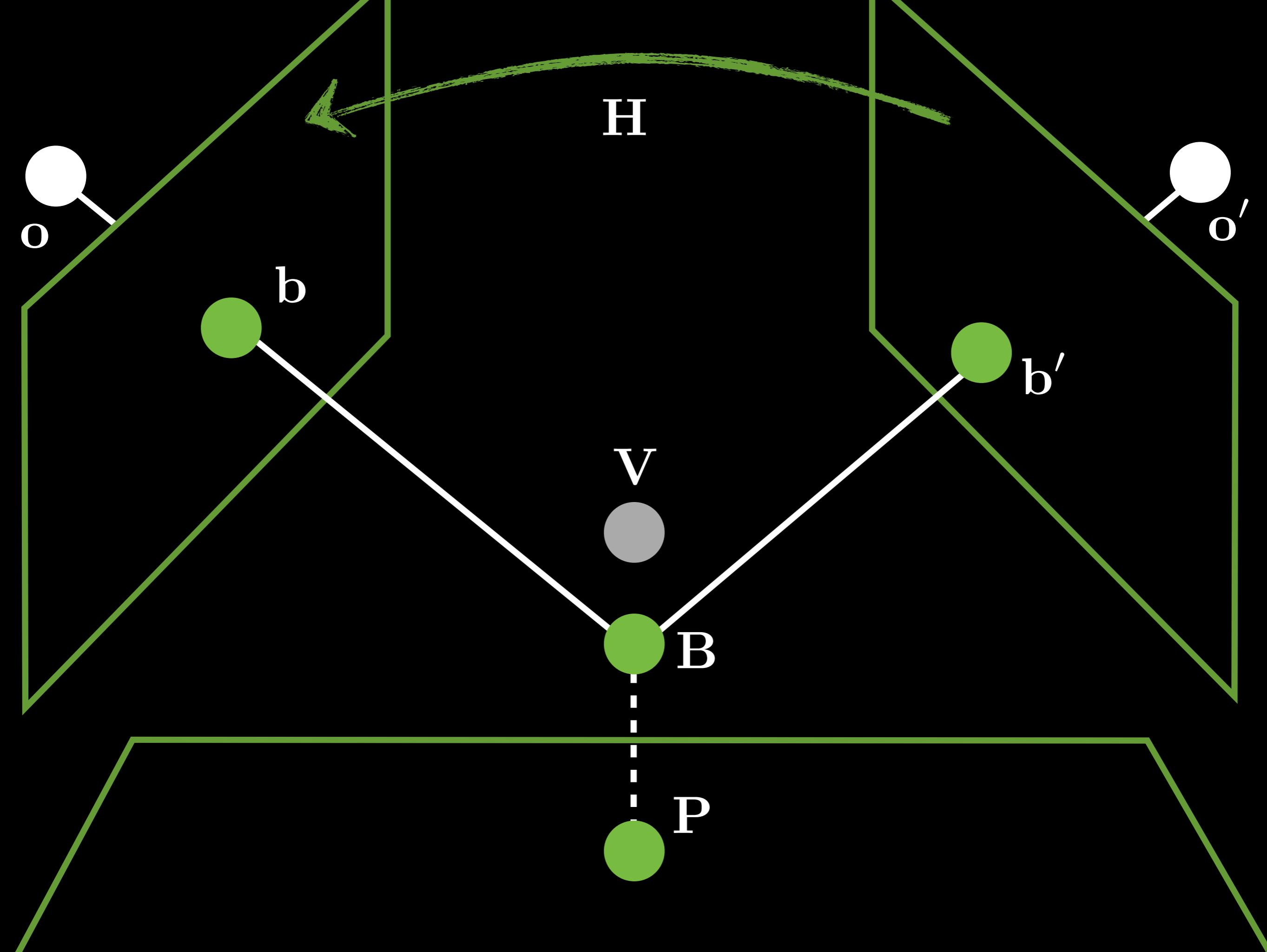


01 : 07 : 51 : 04



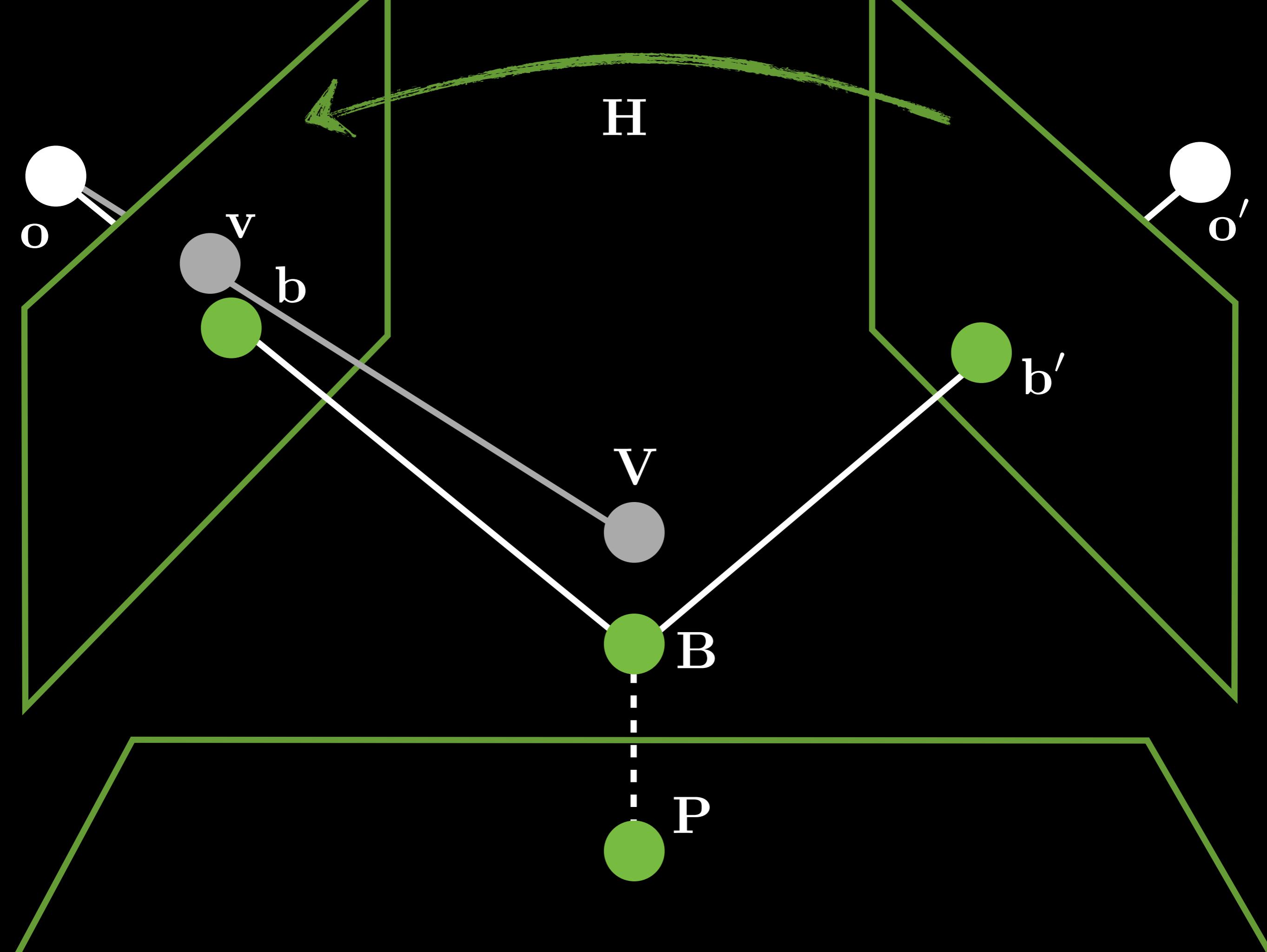
01:07:51 - 04

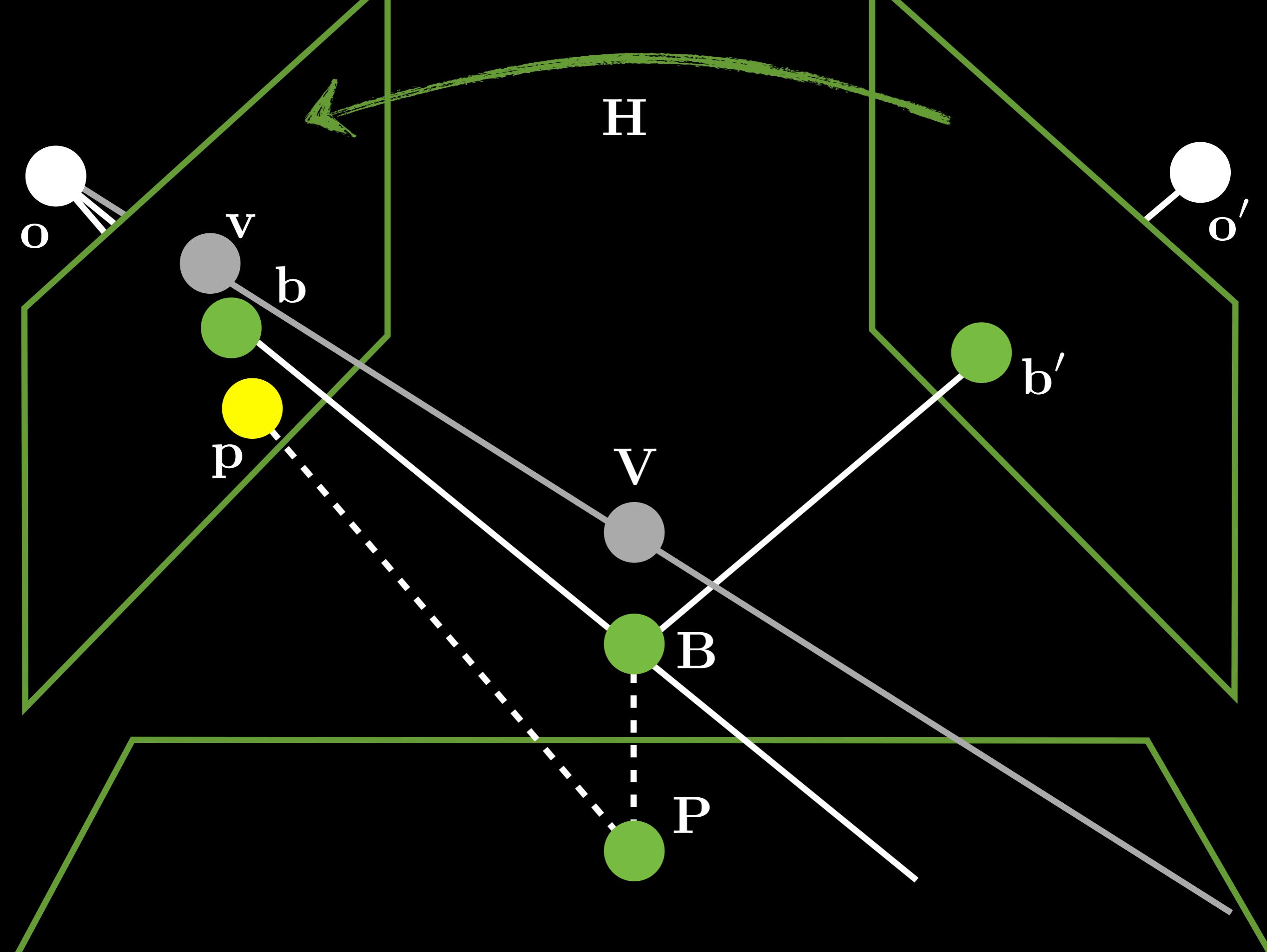


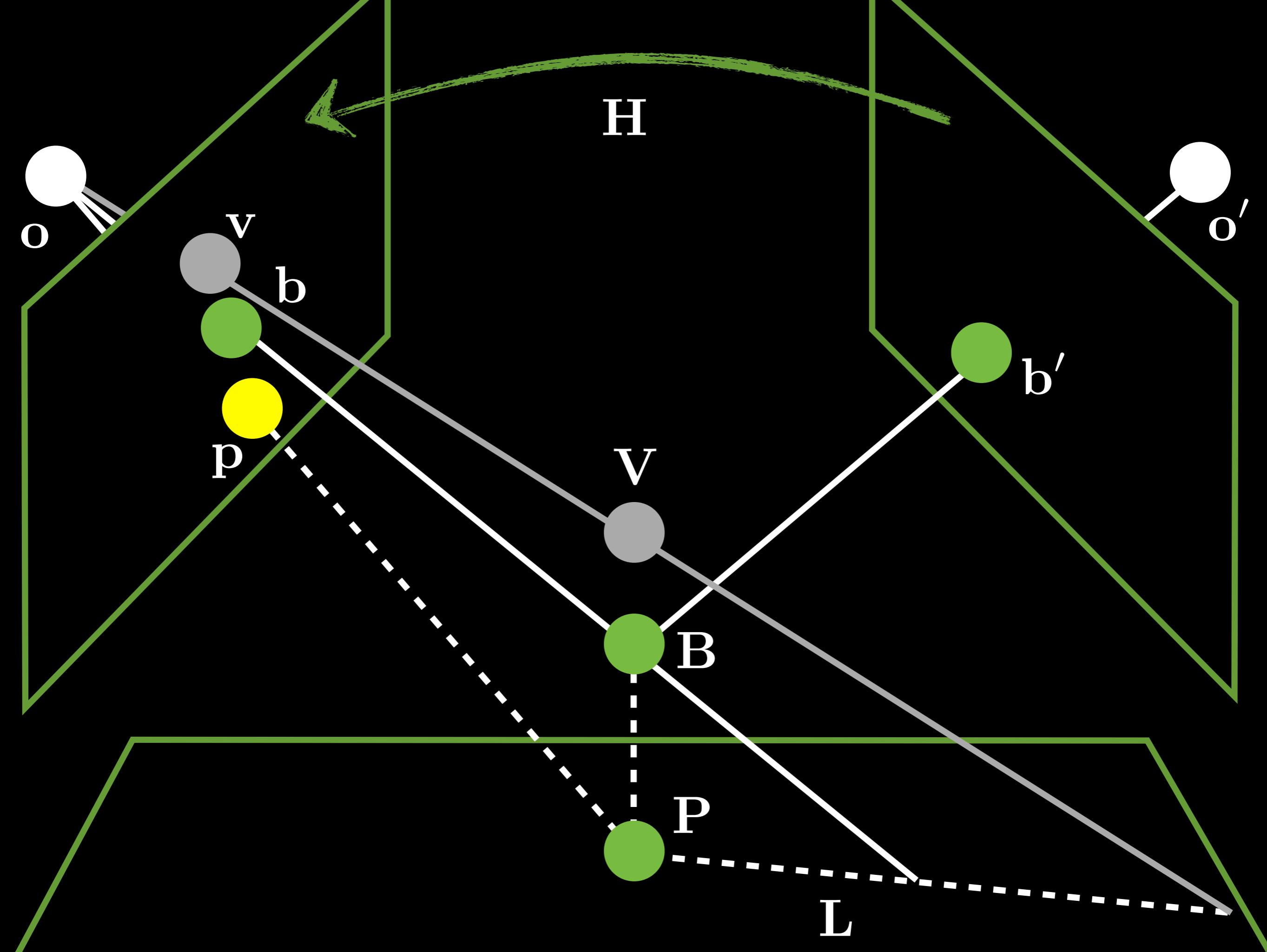


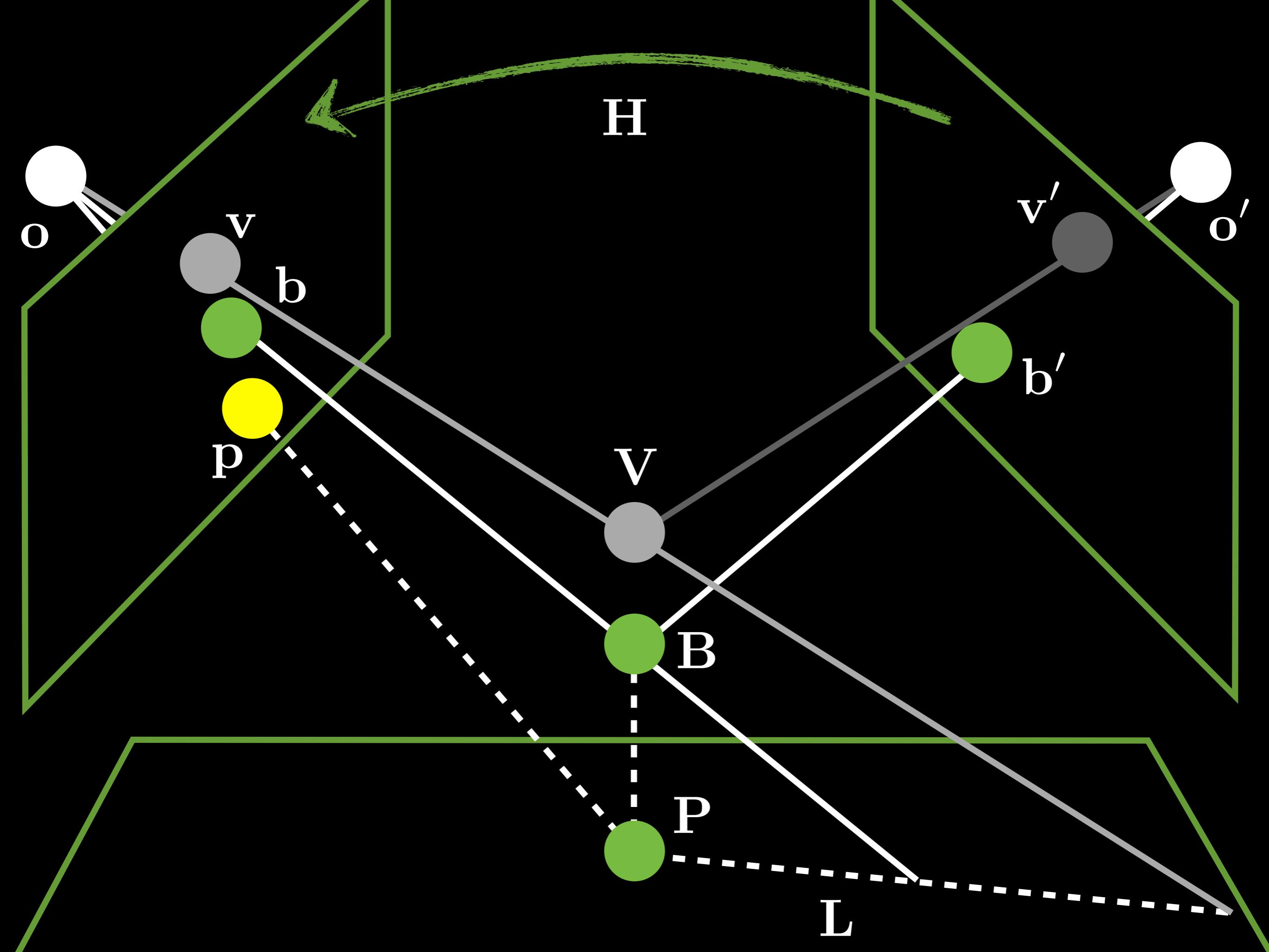


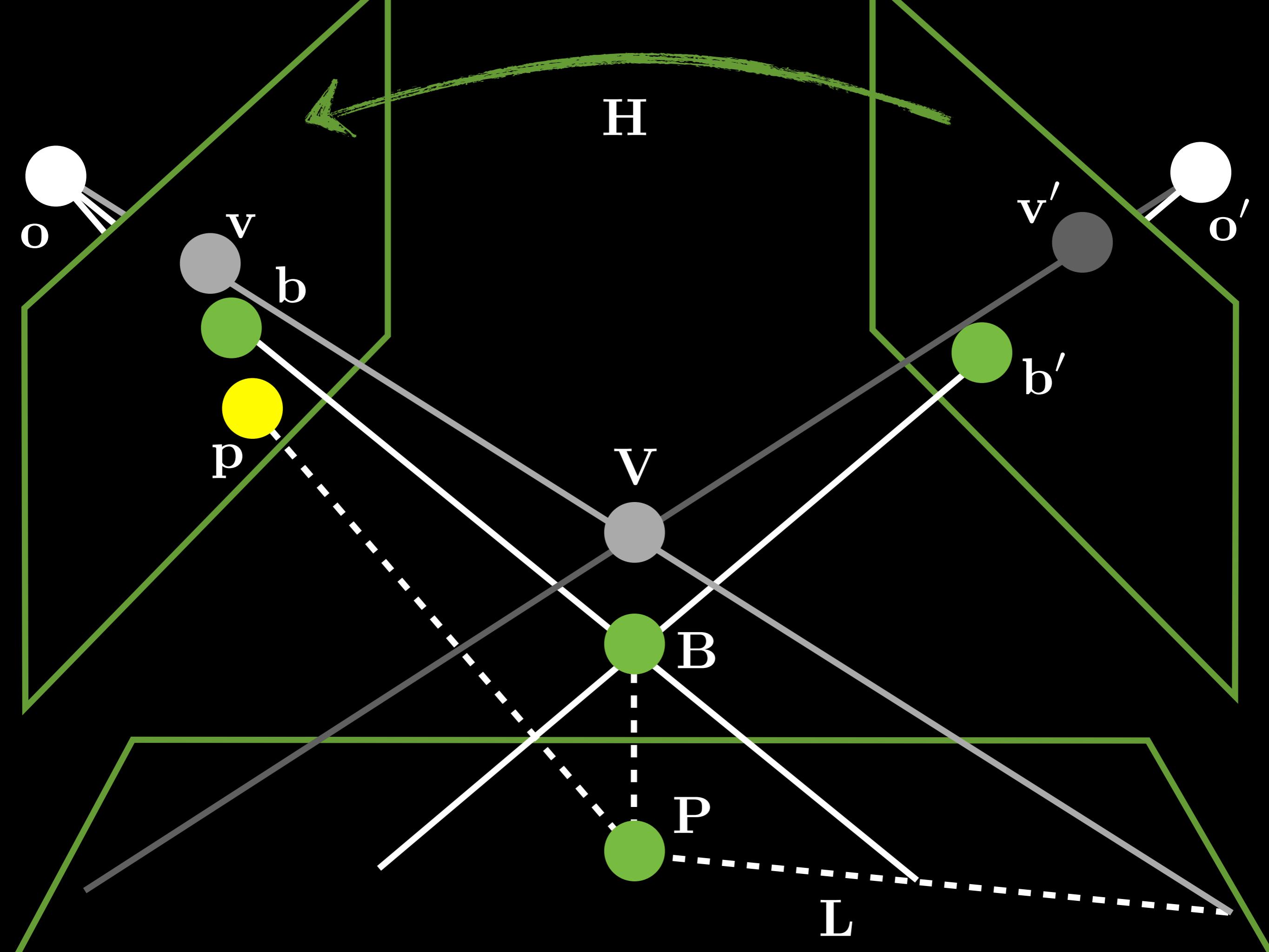
01 : 07 : 51 : 04

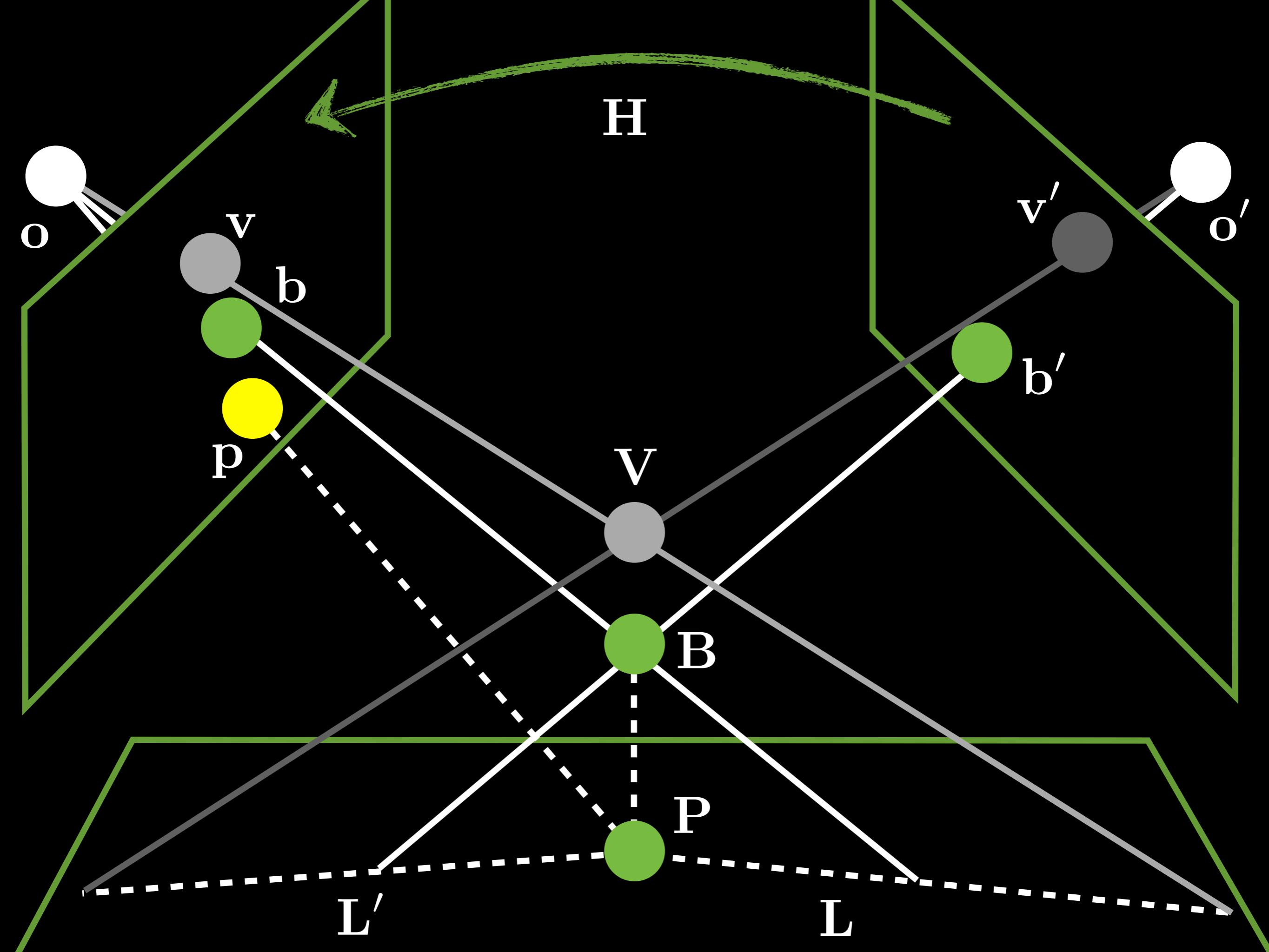


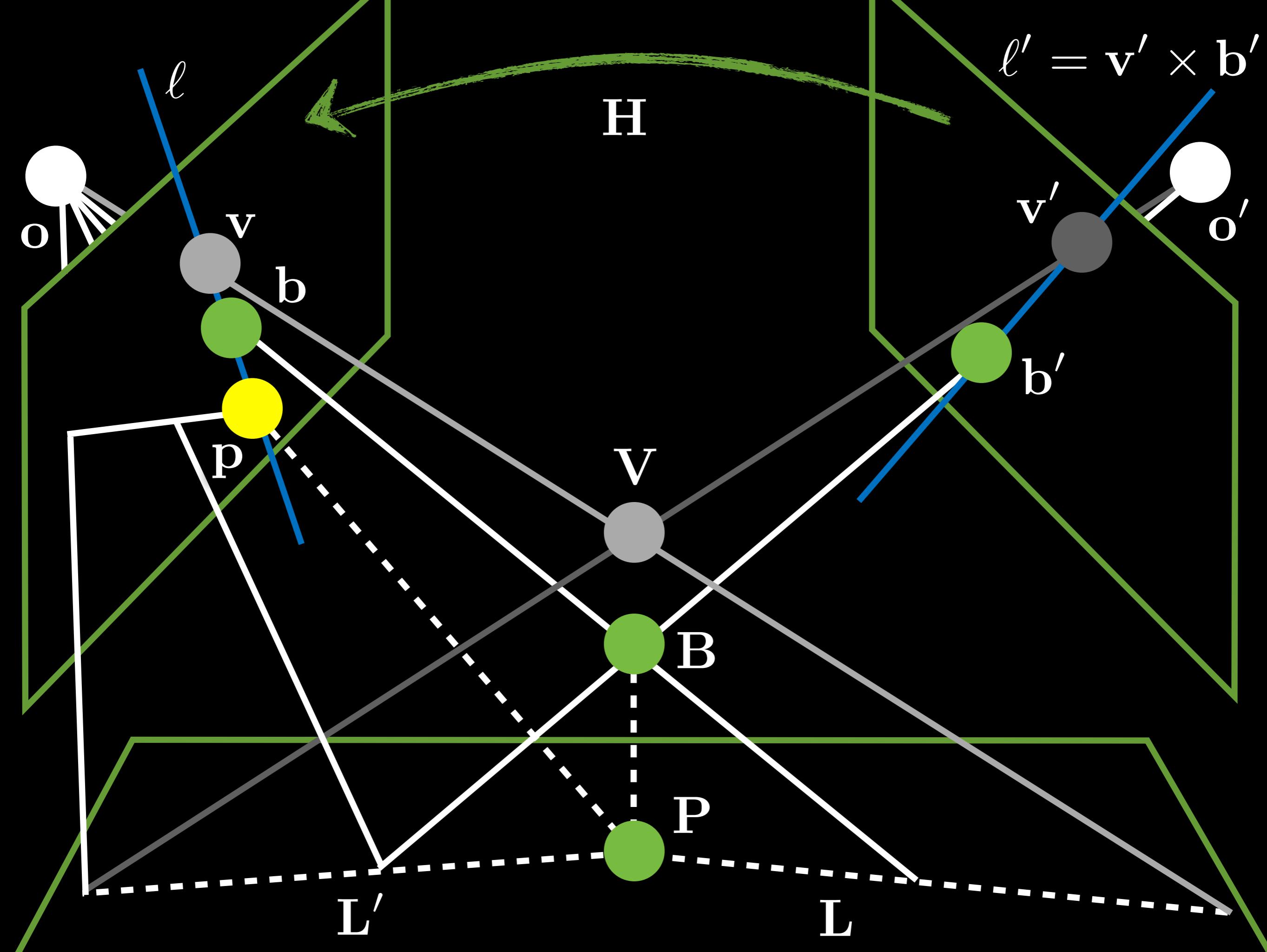


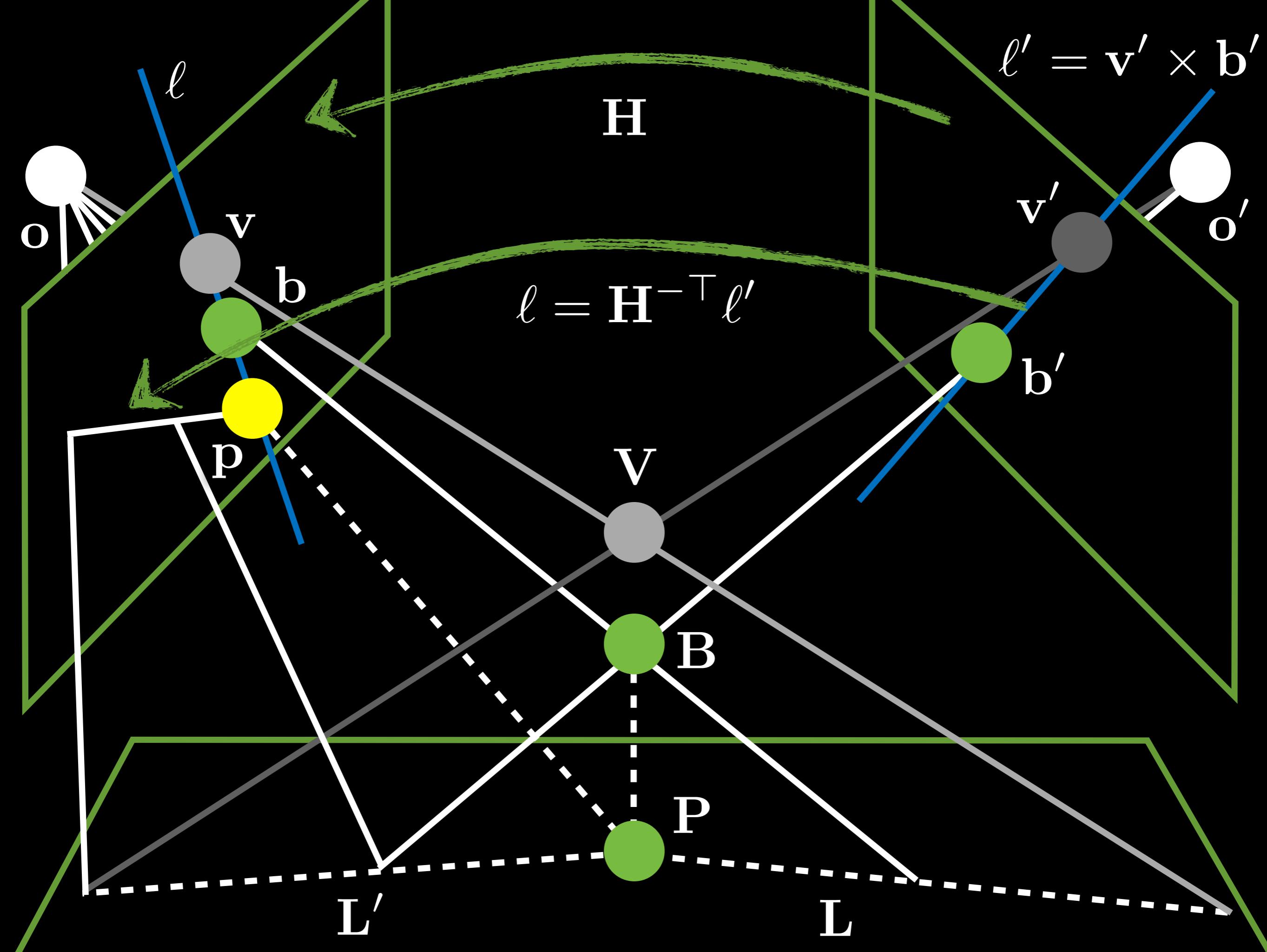


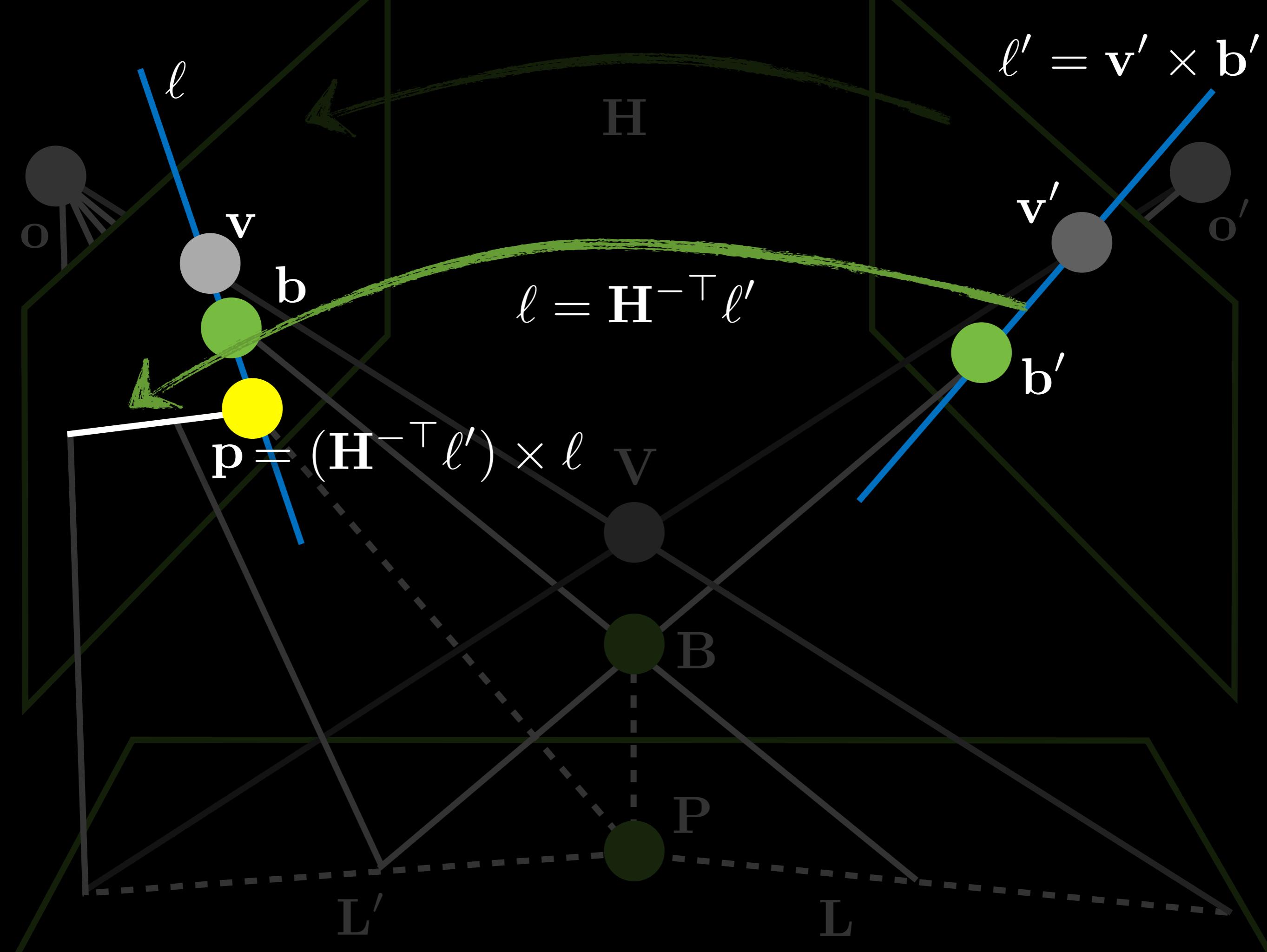


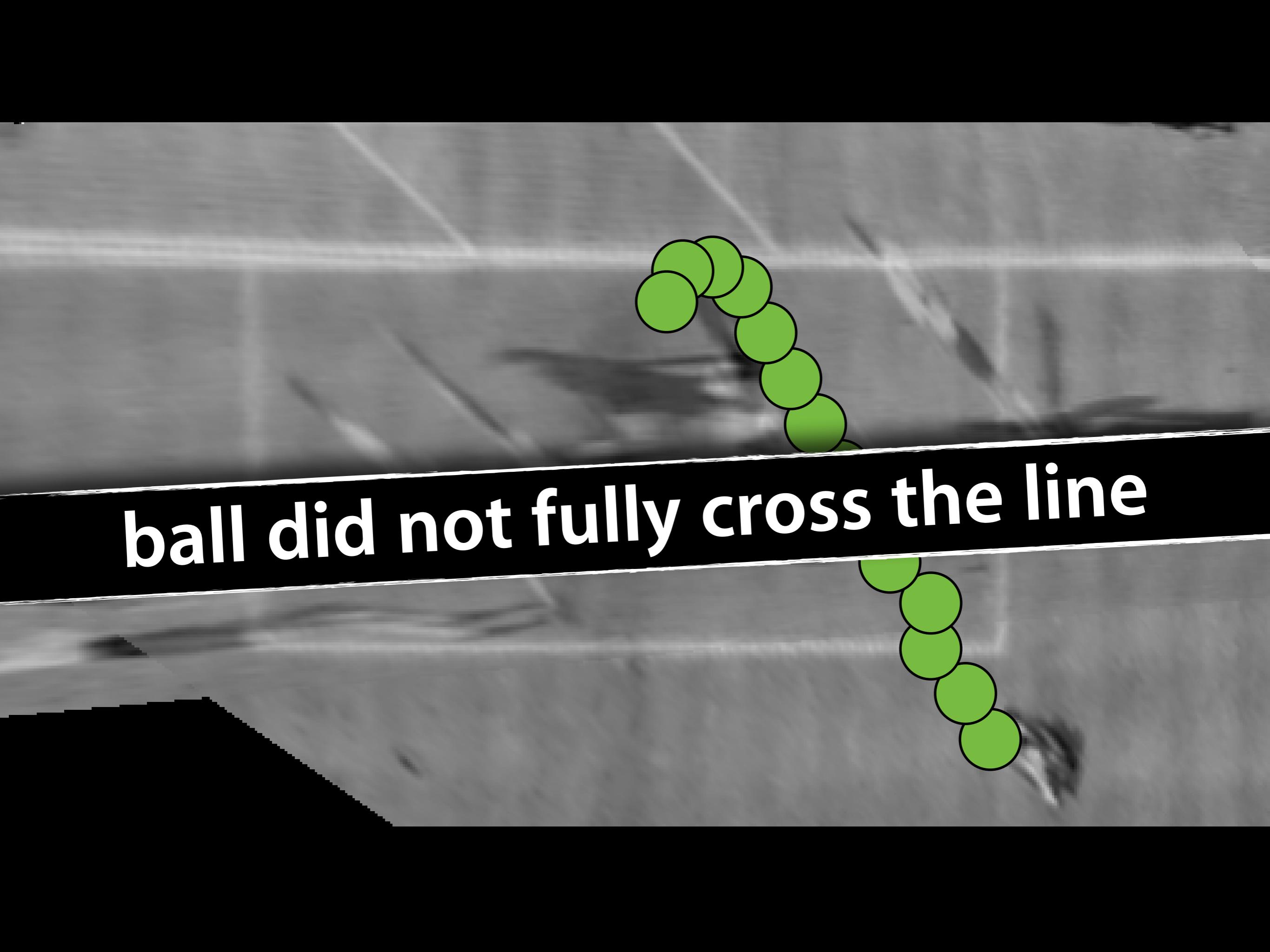












A black and white photograph of a soccer ball. Several bright green circular markers are attached to the ball's surface, forming a curved path that starts near the top left and ends near the bottom right. The ball is positioned on a dark, textured surface, possibly a carpet or mat, which has some faint, illegible markings.

ball did not fully cross the line



goal should not have counted