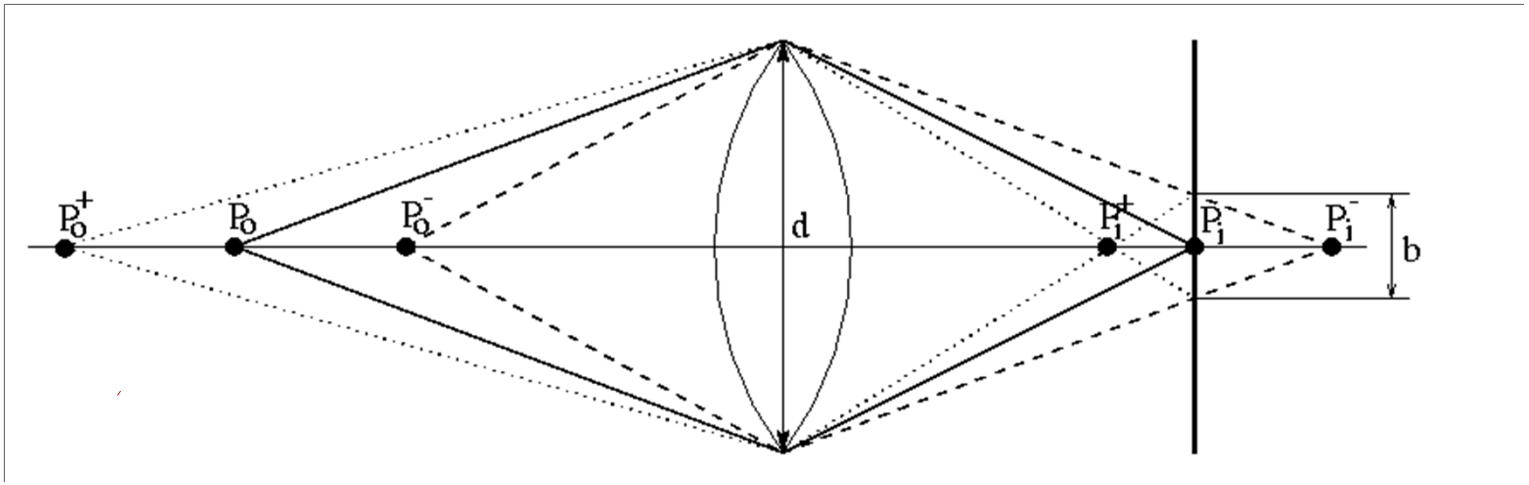
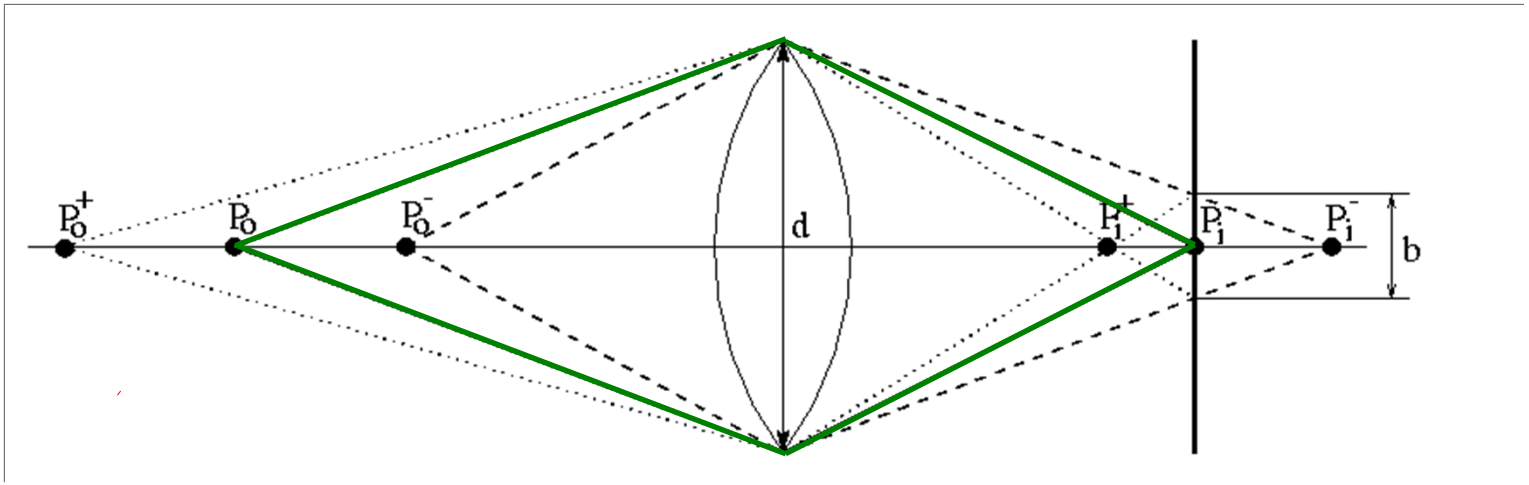
Focus and depth of field

Image credit: cambridgeincolour.com

The depth-of-field



The depth-of-field



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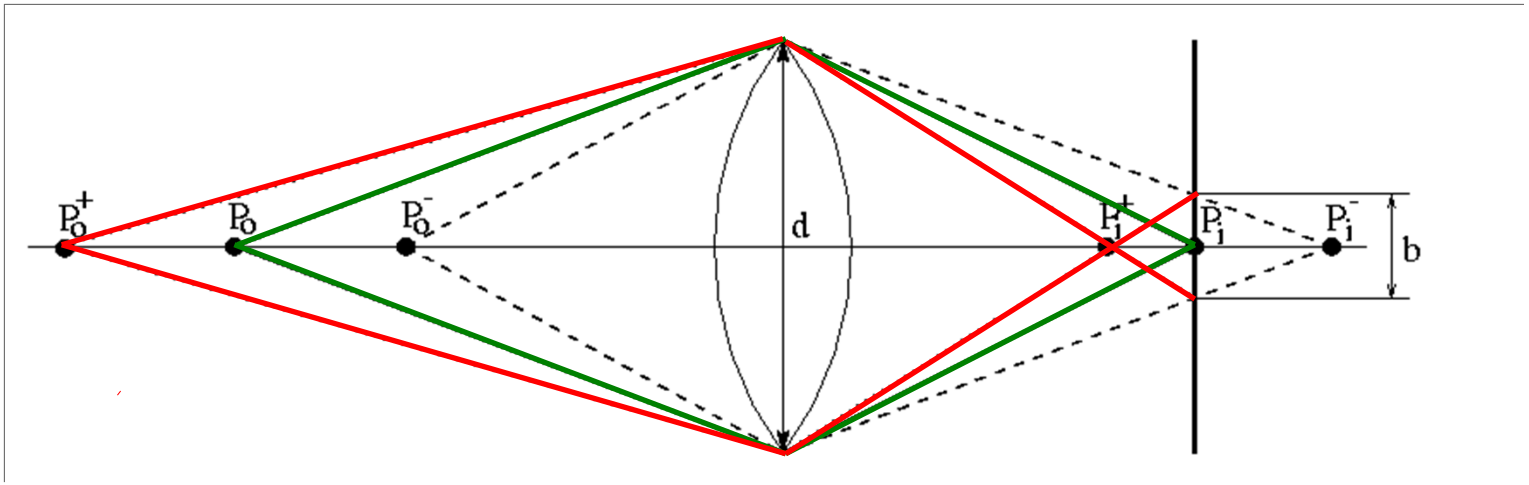

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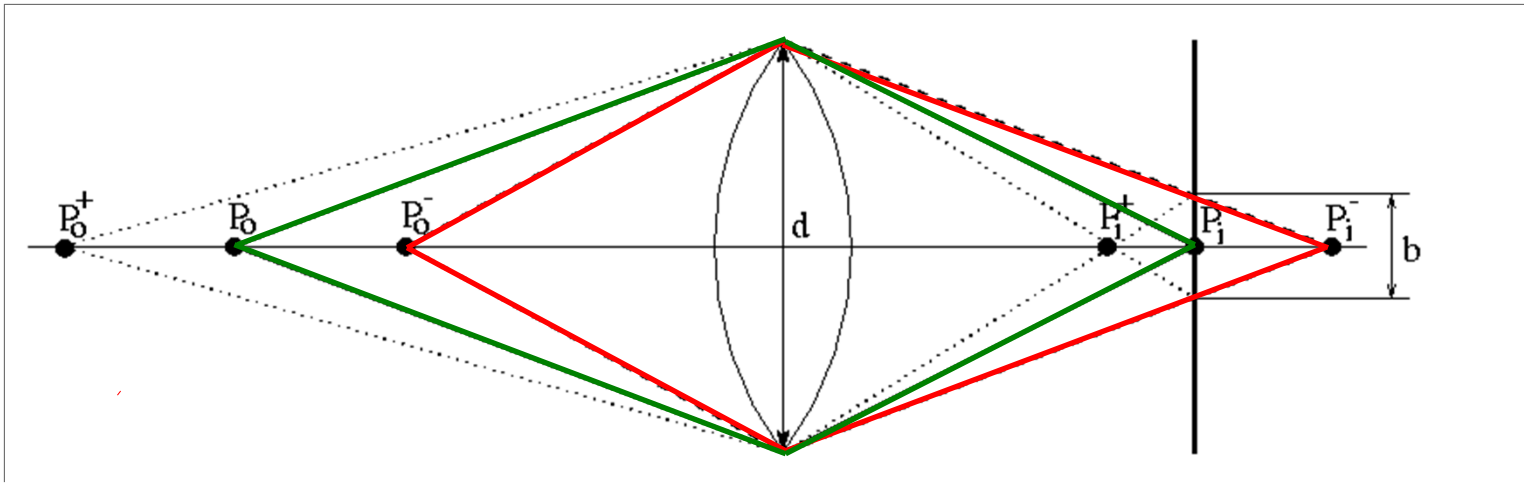
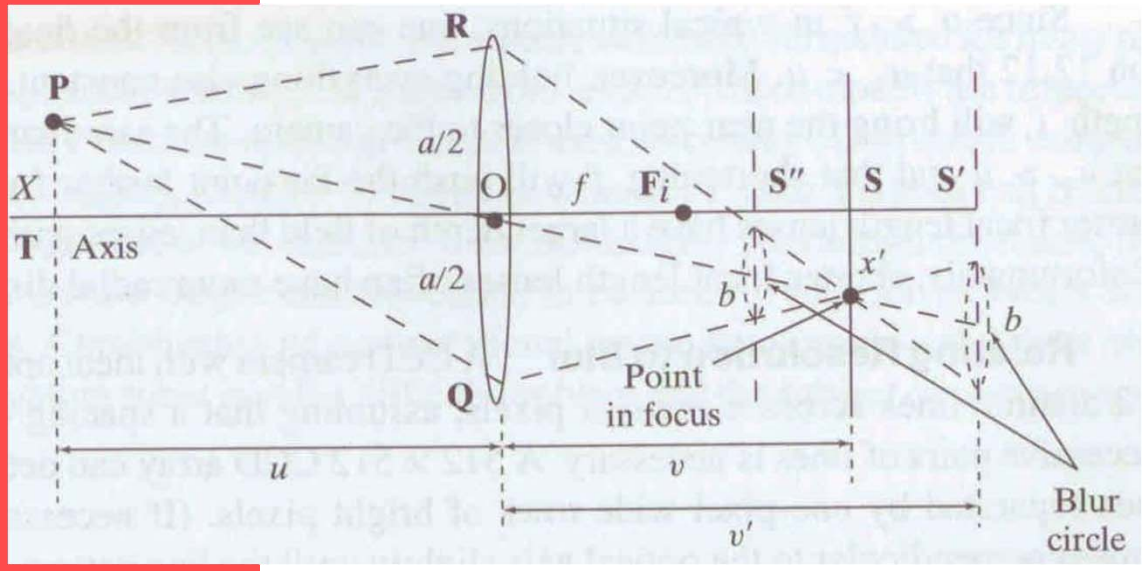


Focus and depth of field

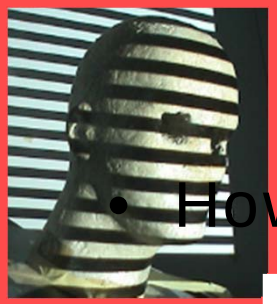
- Depth of field: distance between image planes where blur is tolerable



Thin lens: scene points at distinct depths come in focus at different image planes.

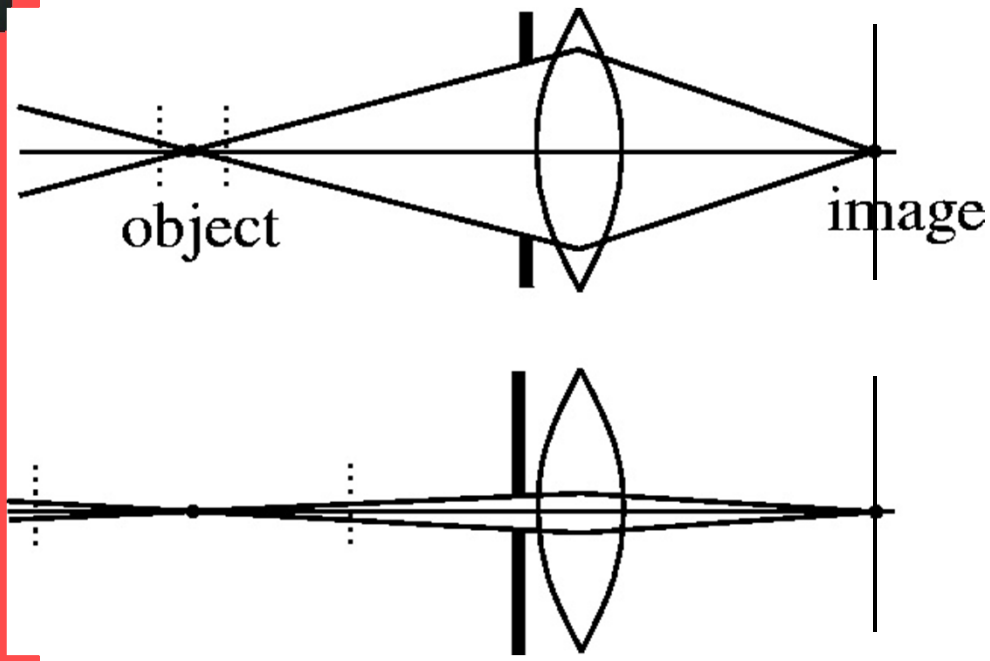
(Real camera lens systems have greater depth of field.)

"circles of confusion"



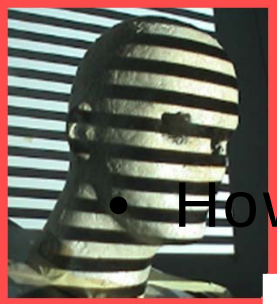
Focus and depth of field

- How does the aperture affect the depth of field?



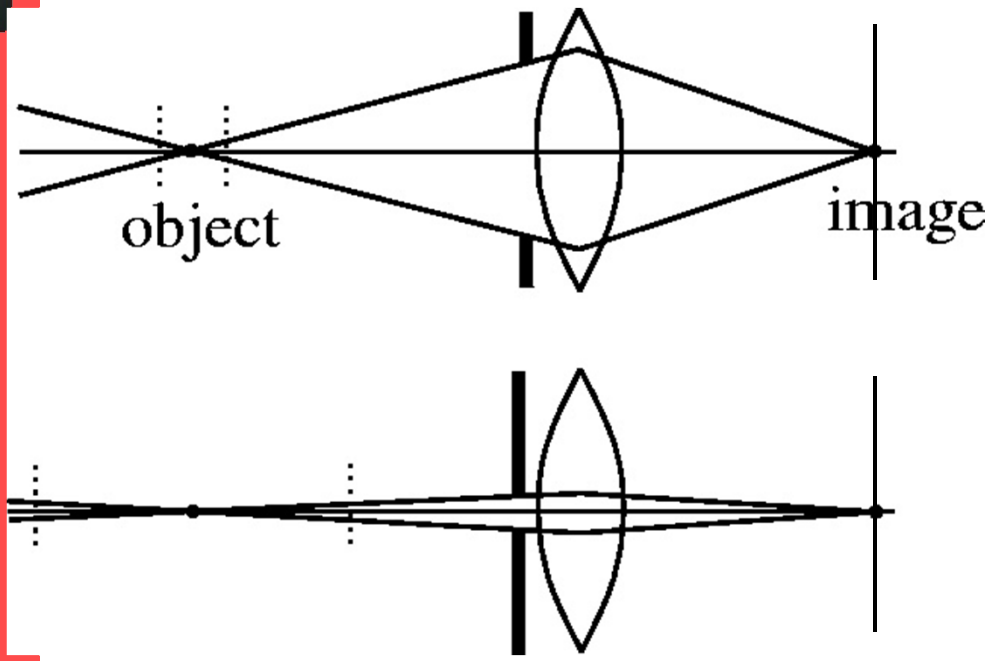
Flower images from Wikipedia http://en.wikipedia.org/wiki/Depth_of_field

Slide from S. Seitz



Focus and depth of field

- How does the aperture affect the depth of field?

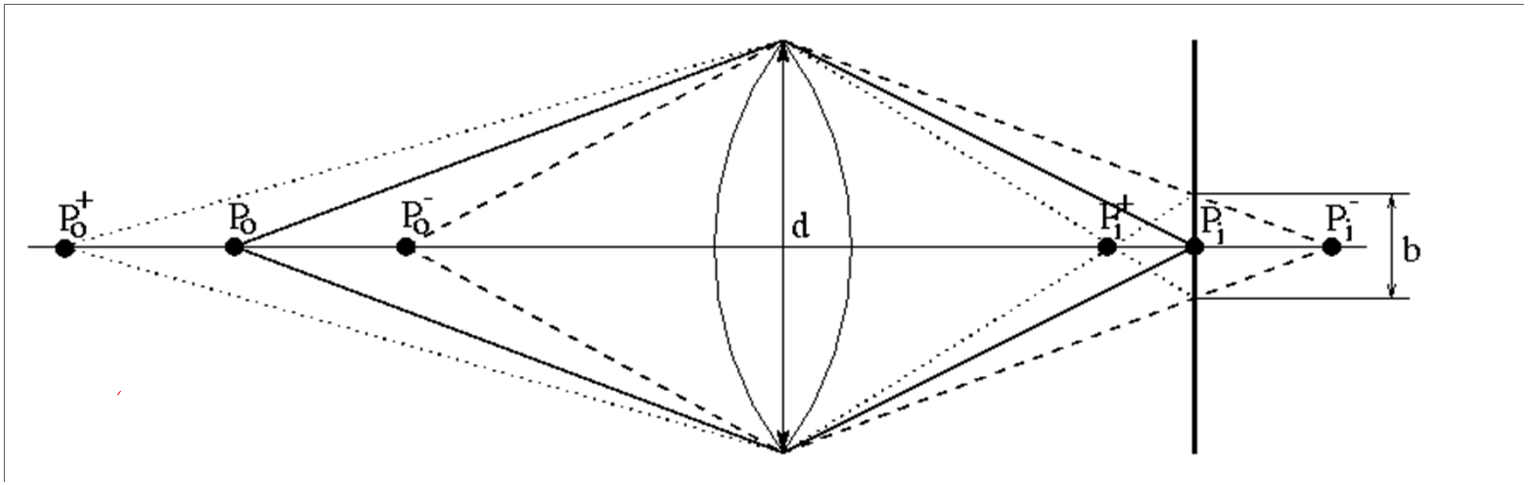


- A smaller aperture increases the range in which the object is approximately in focus

Flower images from Wikipedia http://en.wikipedia.org/wiki/Depth_of_field

Slide from S. Seitz

The depth-of-field



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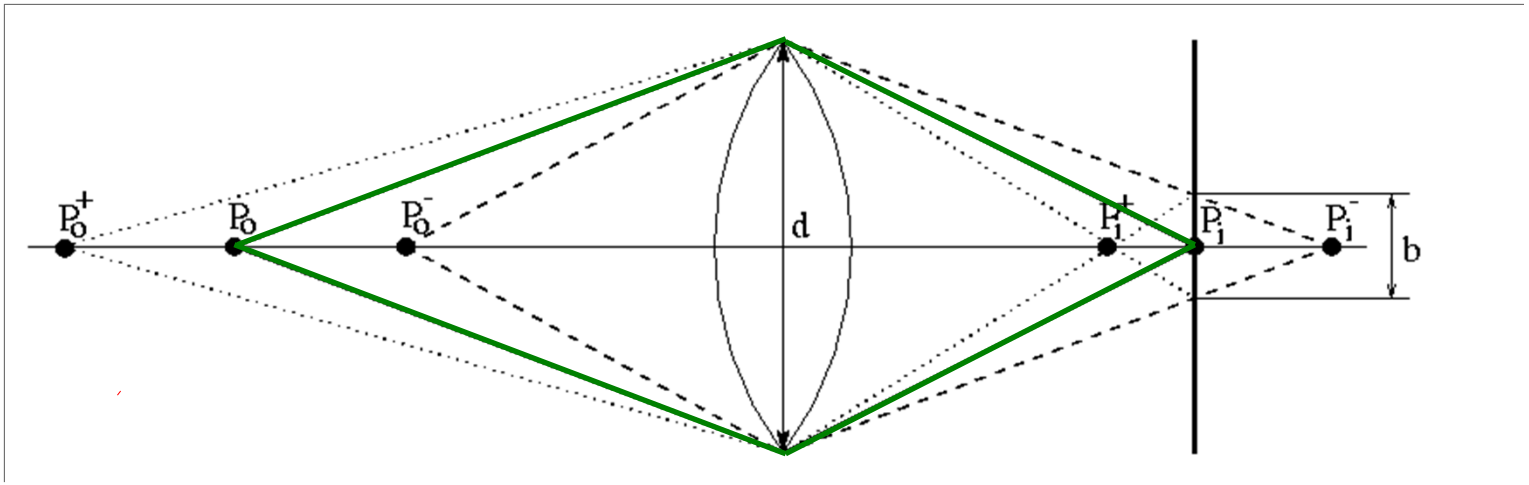
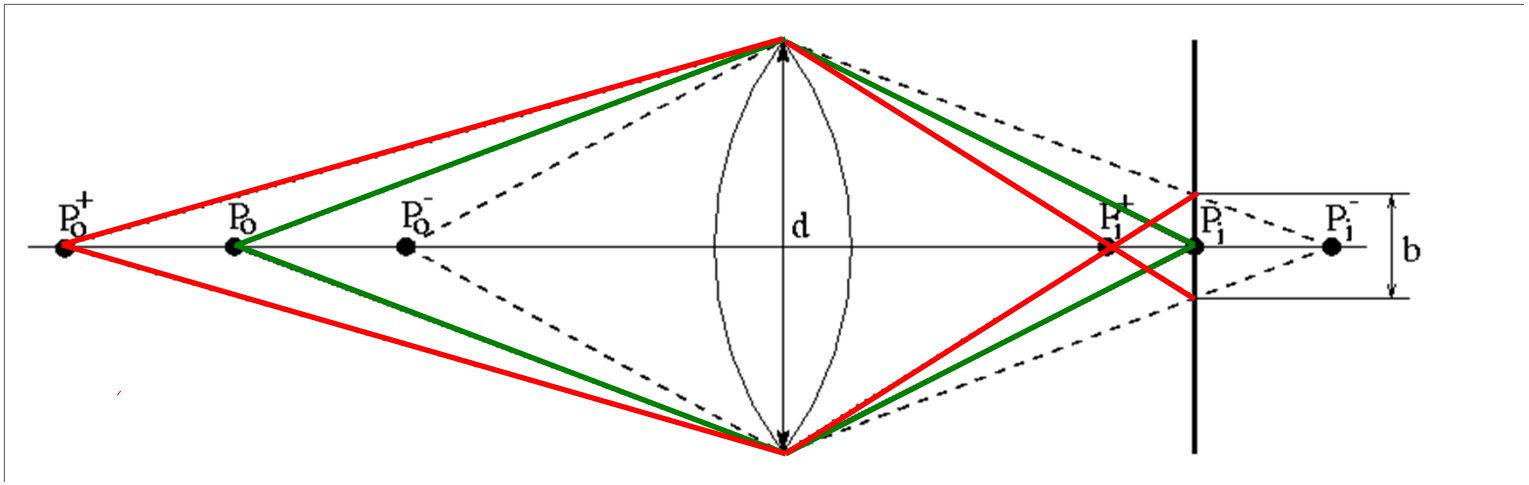


The depth-of-field



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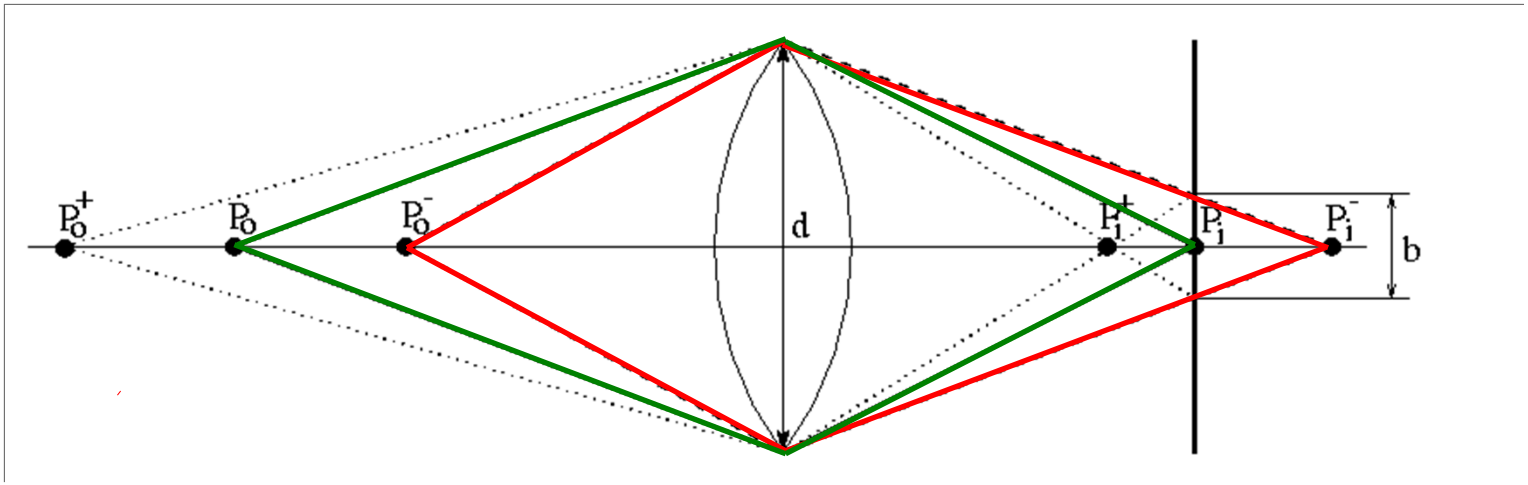
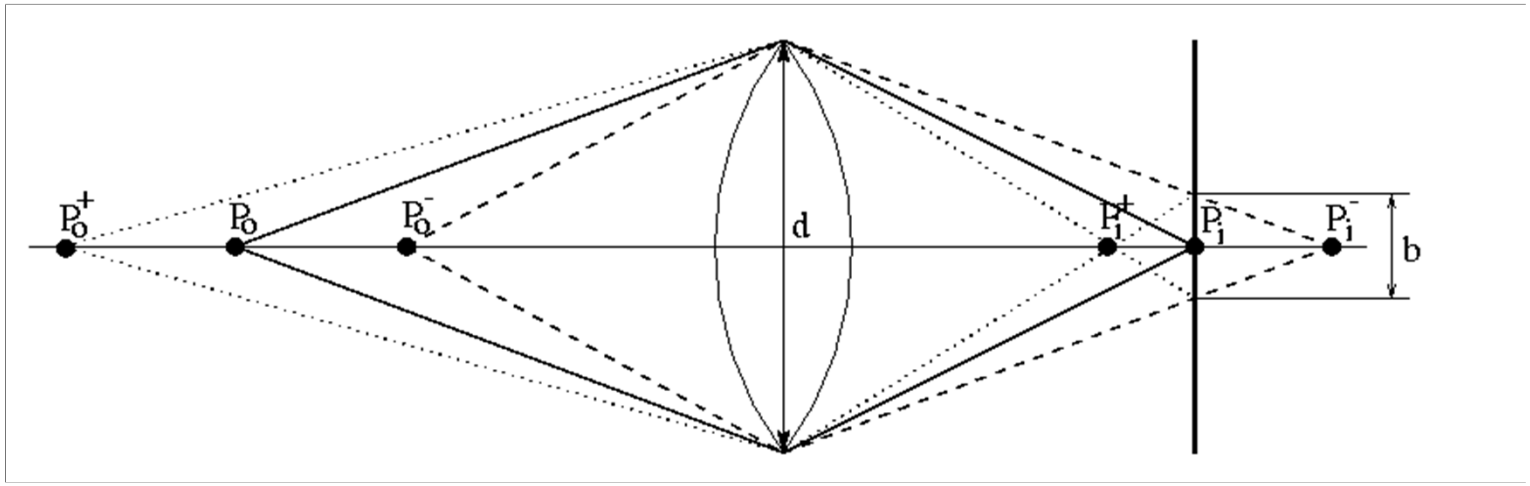


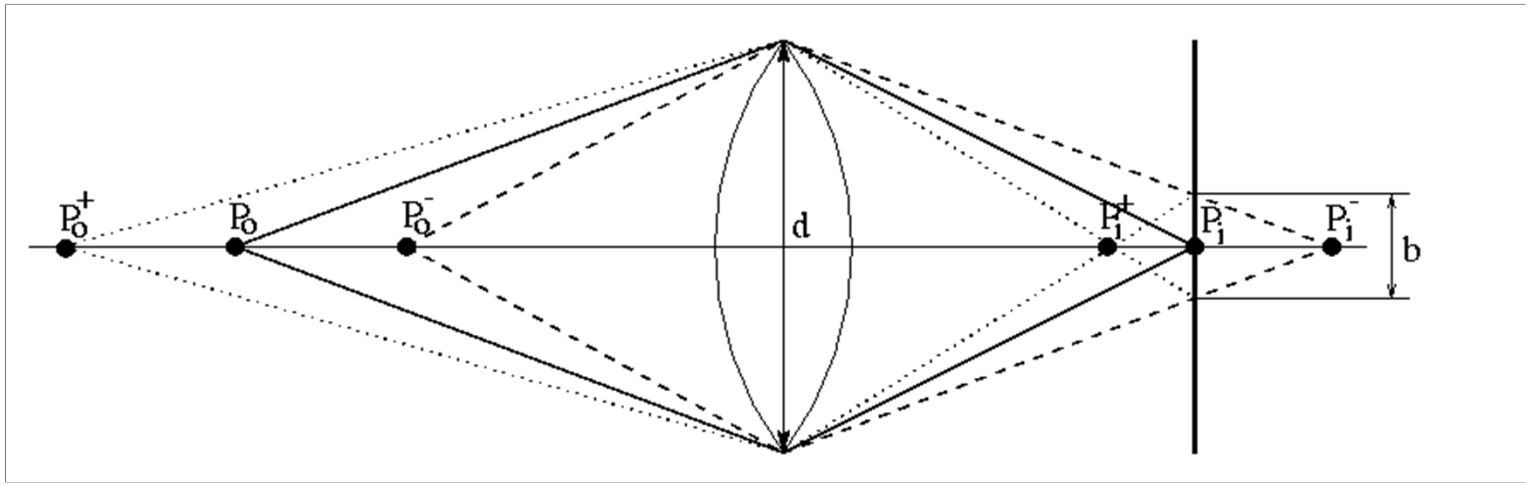
The depth-of-field

$$\frac{1}{Z_o^-} + \frac{1}{\left|Z_i^-\right|} = \frac{1}{f}$$



The depth-of-field

yields $$Z_o^- = f \frac{\left|Z_i^-\right|}{\left|Z_i^-\right| - f}$$



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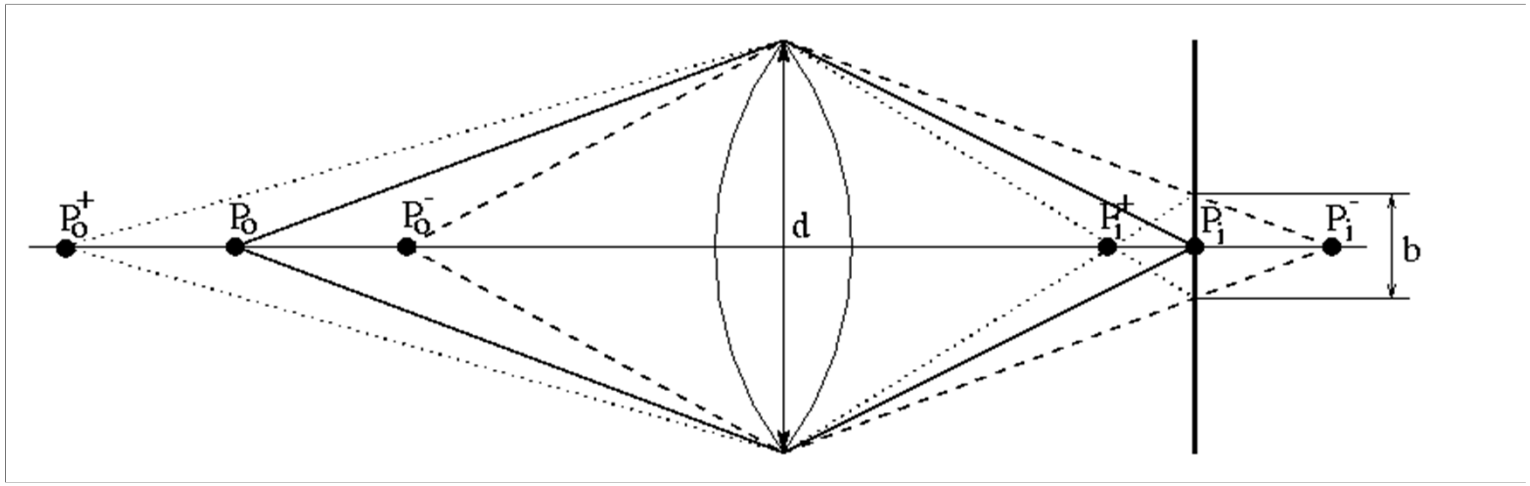
$$\left|Z_i^-\right| = \left|Z_i\right| + \Delta Z_i^-$$



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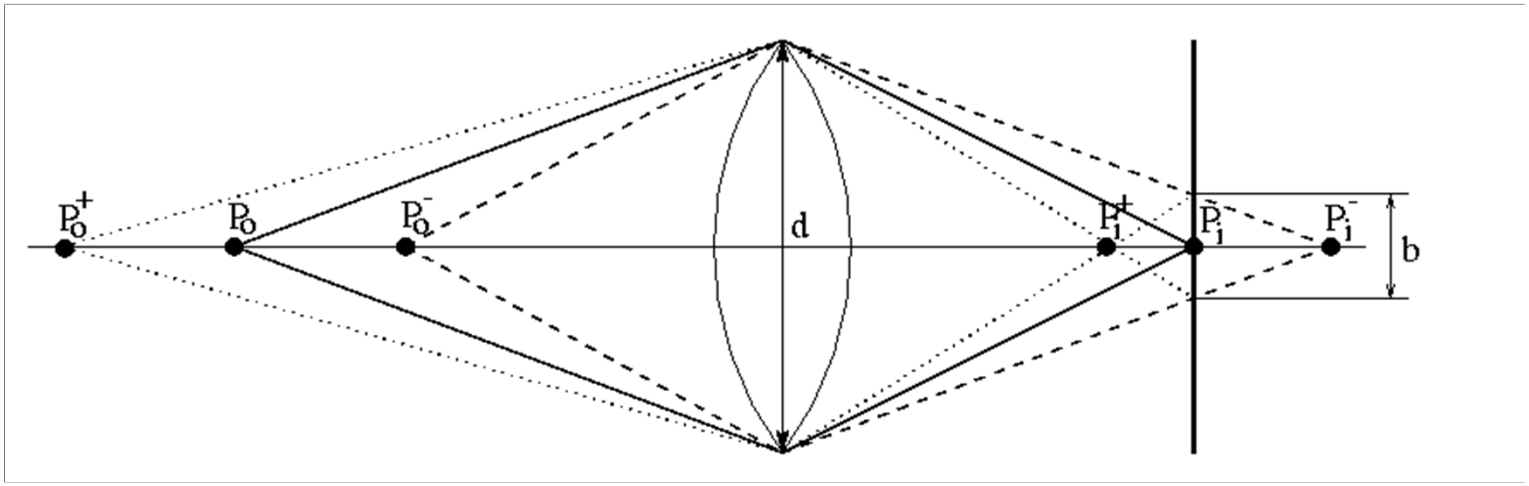
$$\left|Z_i^-\right| = \left|Z_i\right| + \Delta Z_i^-$$

$$\frac{\Delta Z_i^-}{b} = \frac{\left|Z_i\right| + \Delta Z_i^-}{d}$$



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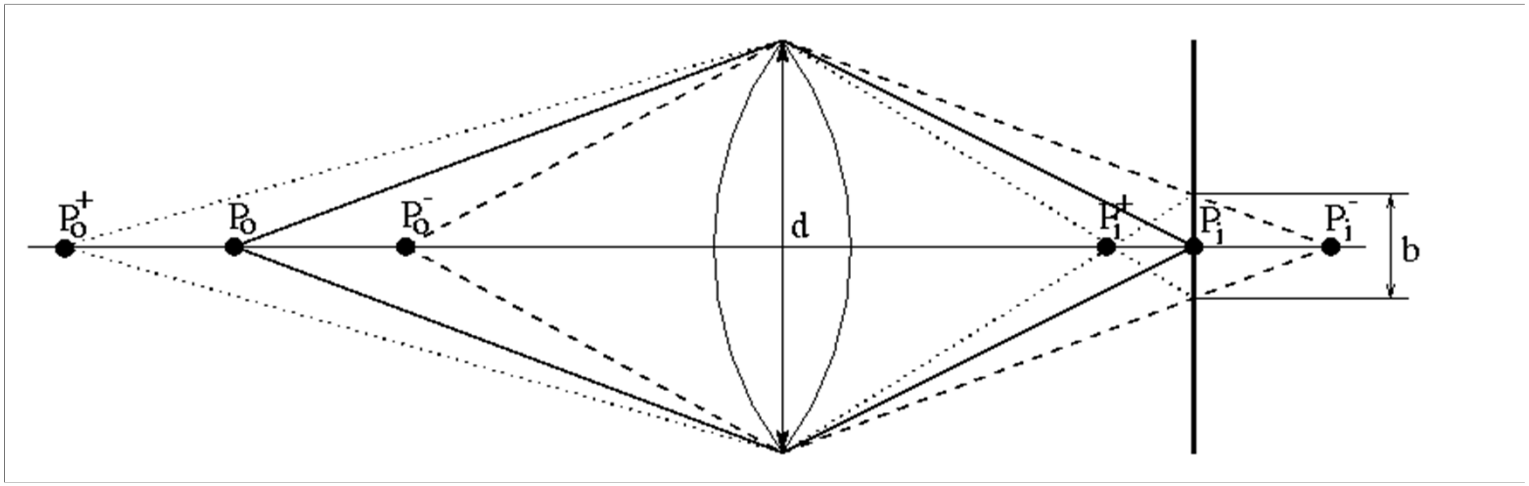
$$\Delta Z_i^- = \frac{b}{d-b}\left|Z_i\right|$$



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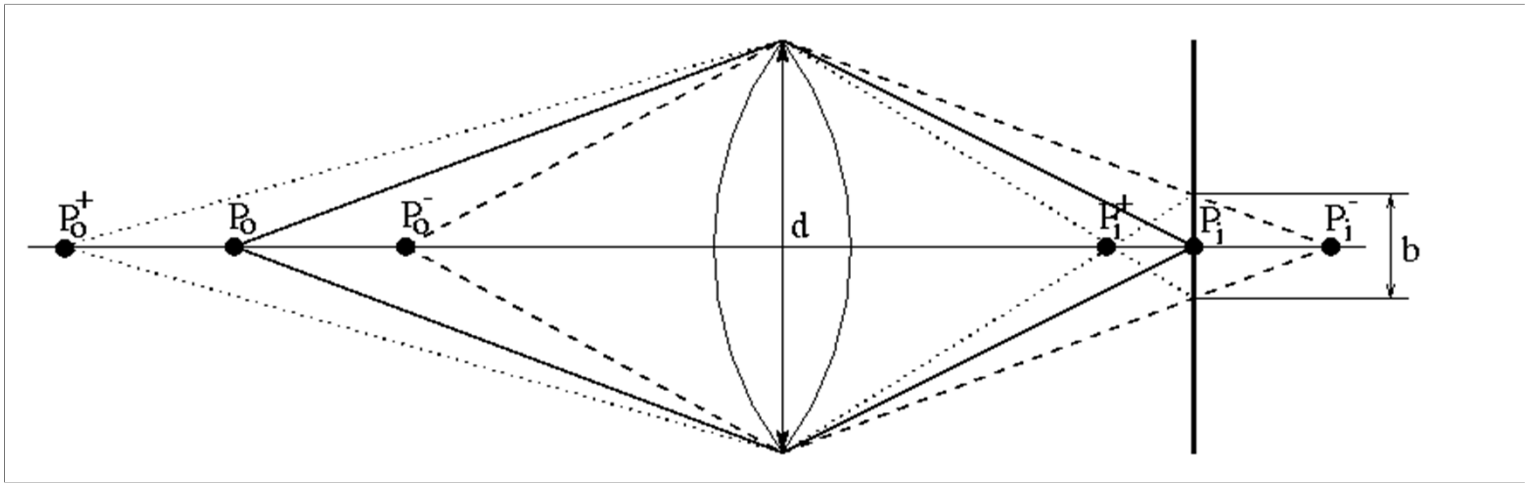

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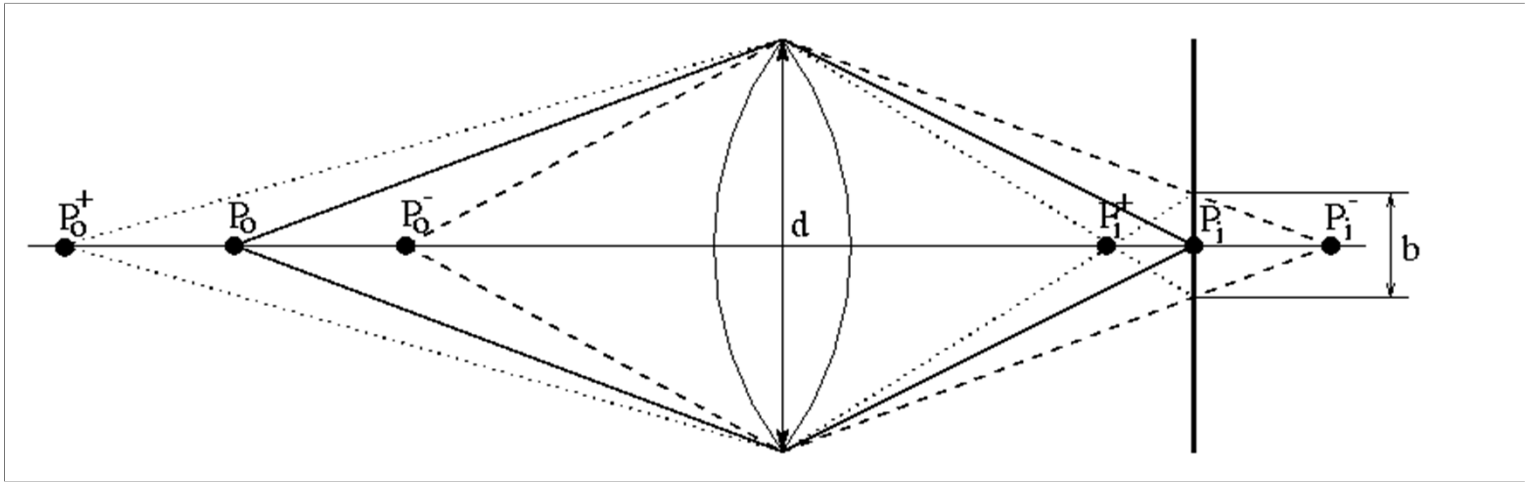
$$\left|Z_i^-\right| = \left|Z_i\right| d/(d-b)$$

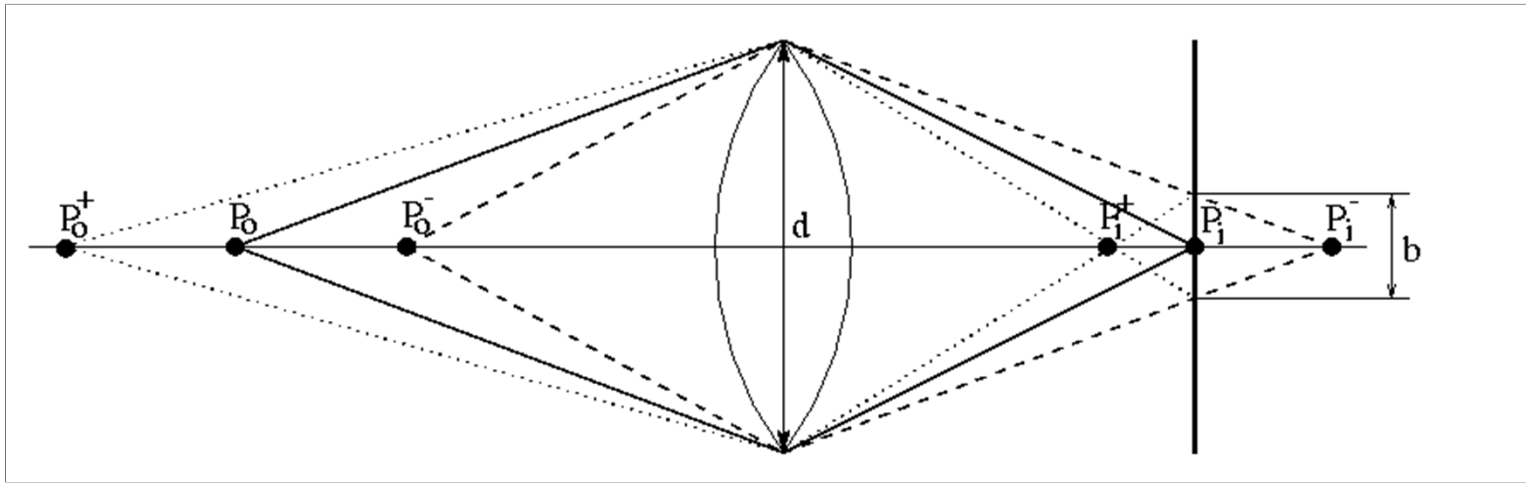


The depth-of-field

yields $$Z_o^- = f\,\frac{|Z_i^-|}{|Z_i^-| - f}$$

$$|Z_i| = \frac{f\ Z_o}{Z_o - f}$$

$$|Z_i^-| = |Z_i|\, d/(d-b)$$



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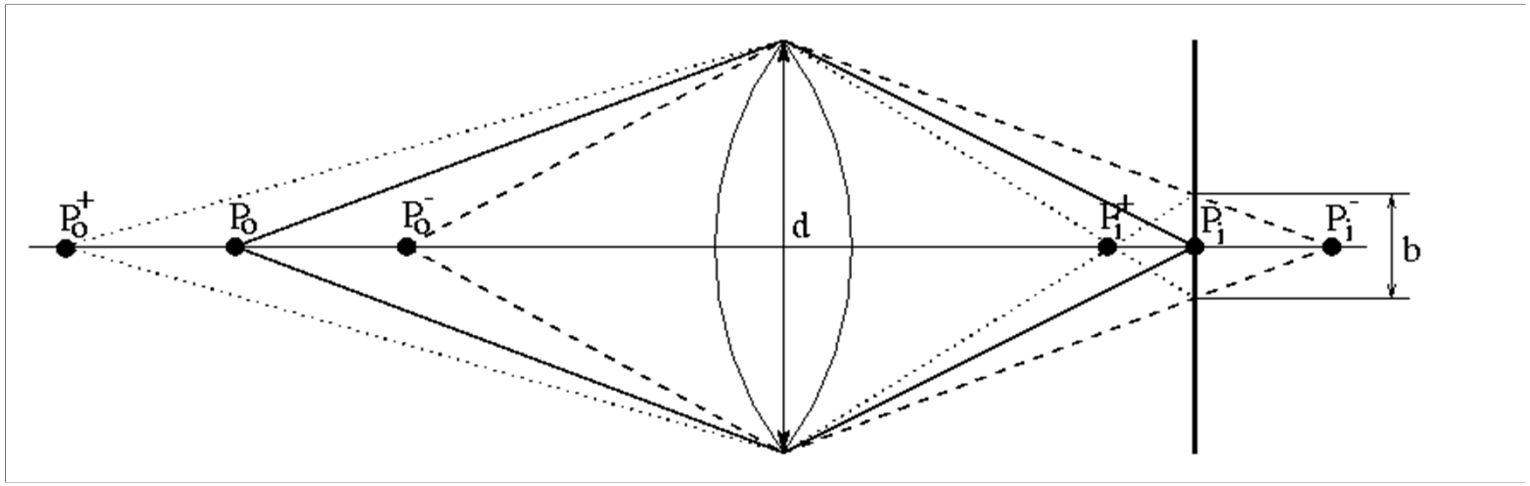

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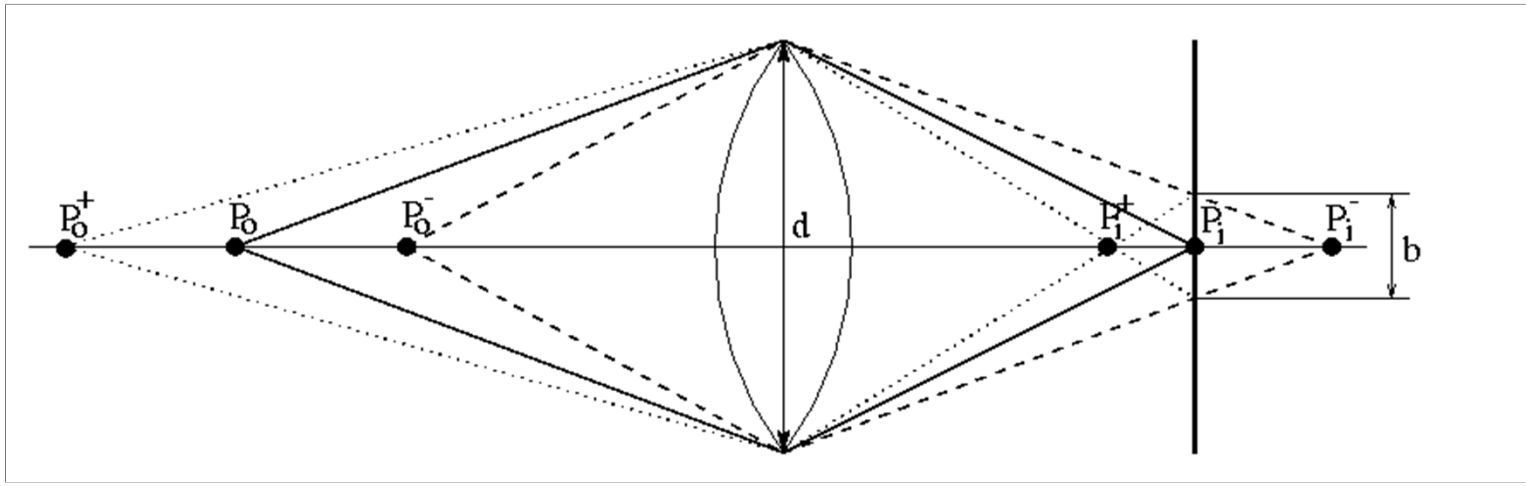
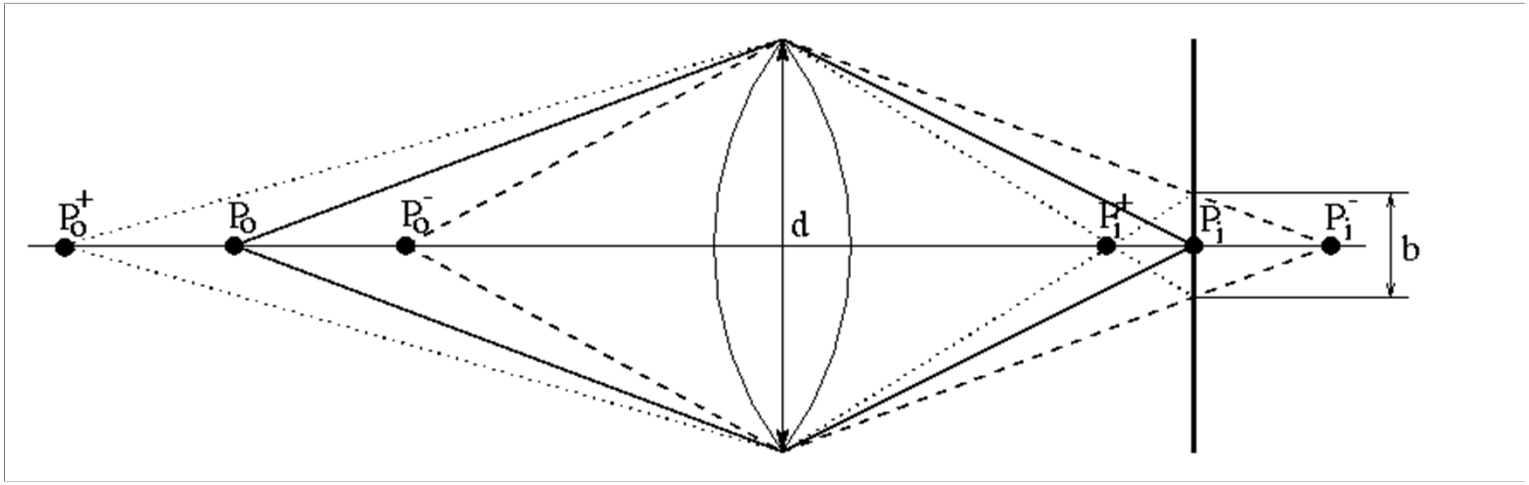


The depth-of-field

yields $$Z_o^- = f \frac{\left|Z_i^-\right|}{\left|Z_i^-\right| - f}$$

$$Z_o^- = f \frac{d\, Z_o}{b\, Z_0 + f\,(d-b)}$$



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$$Z_o^- = f \frac{d\, Z_o}{b\, Z_0 + f\,(d-b)}$$

$$\Delta Z_o^- = Z_o - Z_o^- = \frac{Z_o\,(Z_o - f)}{Z_0 + f\, d/b - f}$$

The depth-of-field

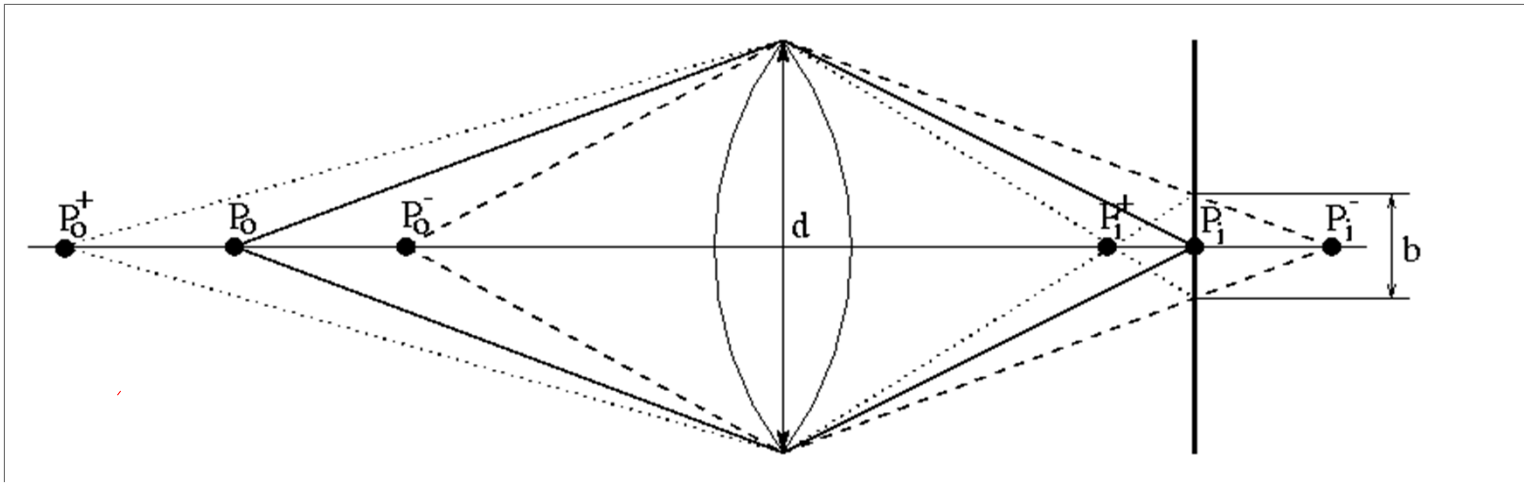
yields $$Z_o^- = f \frac{\left|Z_i^-\right|}{\left|Z_i^-\right| - f}$$

$$Z_o^- = f \frac{d\, Z_o}{b\, Z_0 + f\,(d-b)}$$

$$\Delta Z_o^- = Z_o - Z_o^- = \frac{Z_o\,(Z_o - f)}{Z_0 + f\,d/b - f}$$

Similar formula for $\Delta Z_o^+ = Z_o^+ - Z_o$

The depth-of-field



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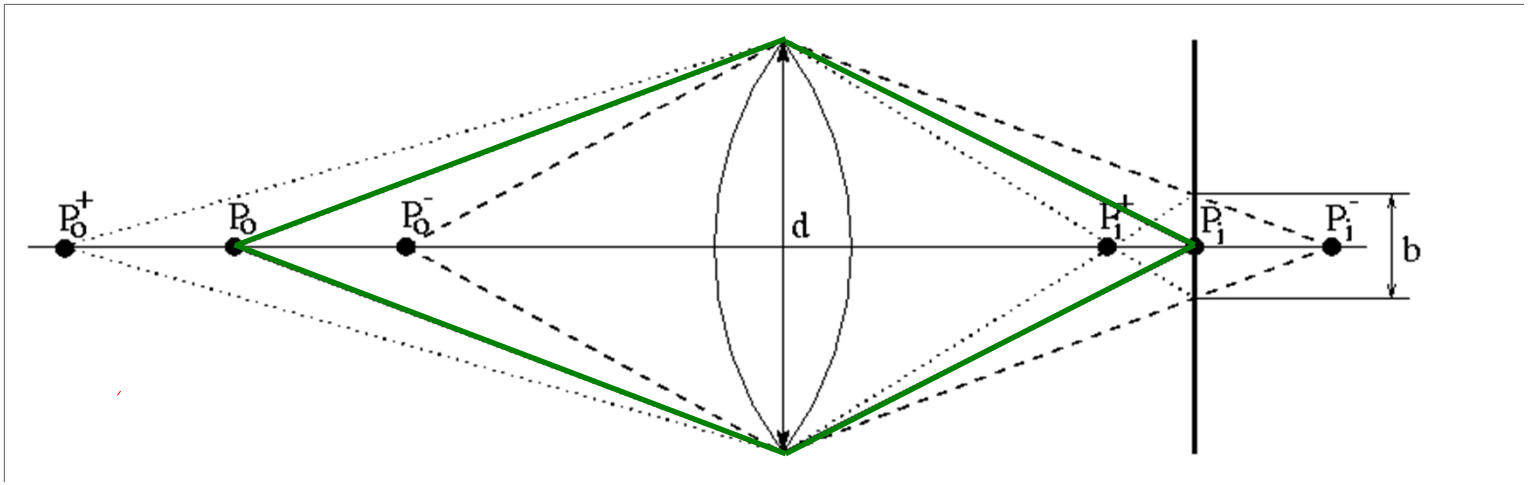

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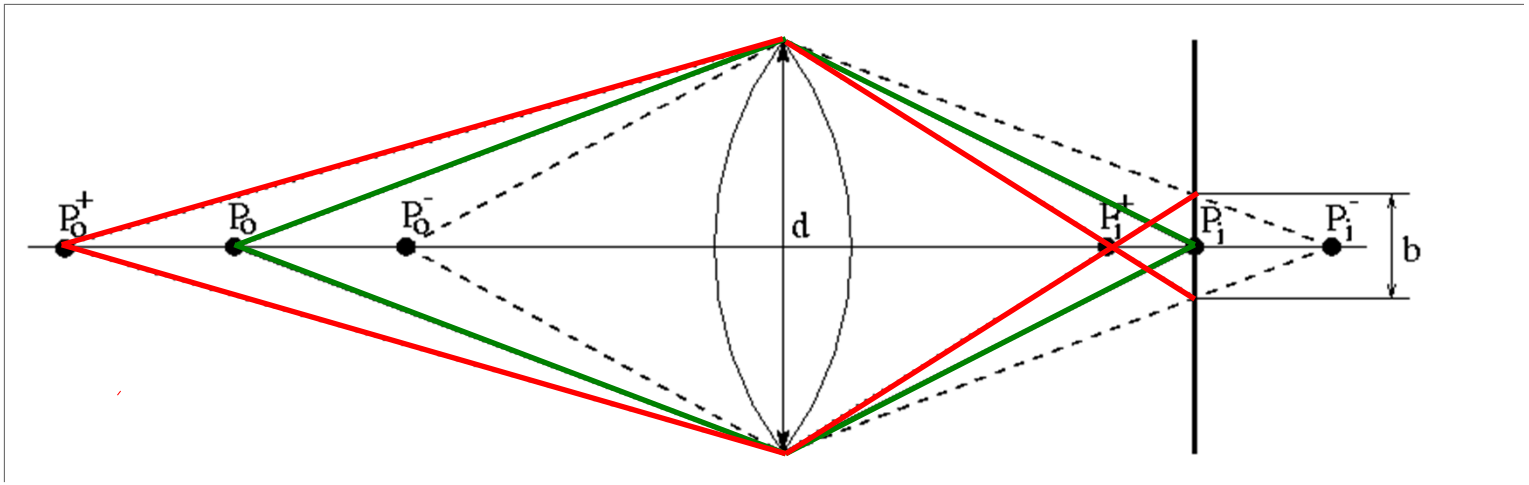

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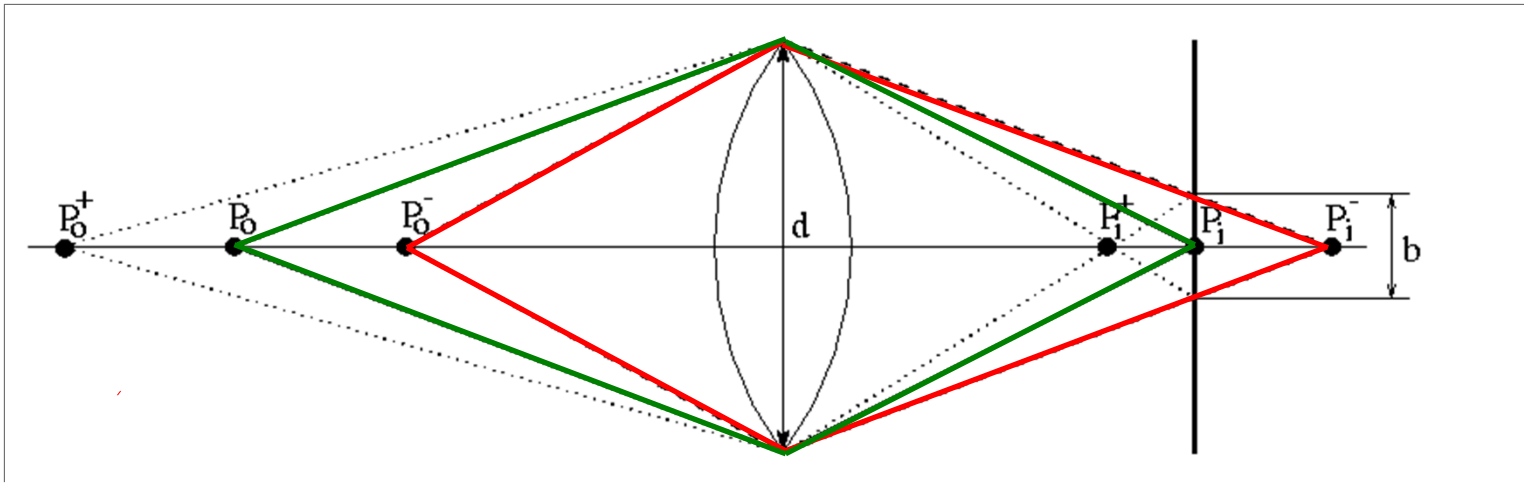

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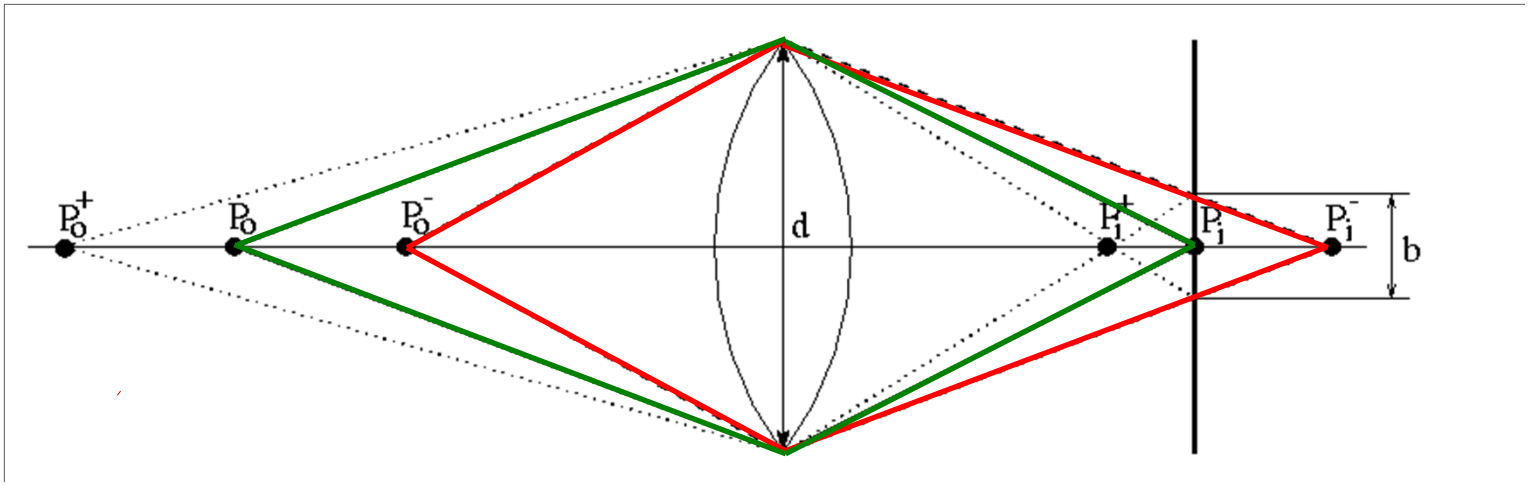
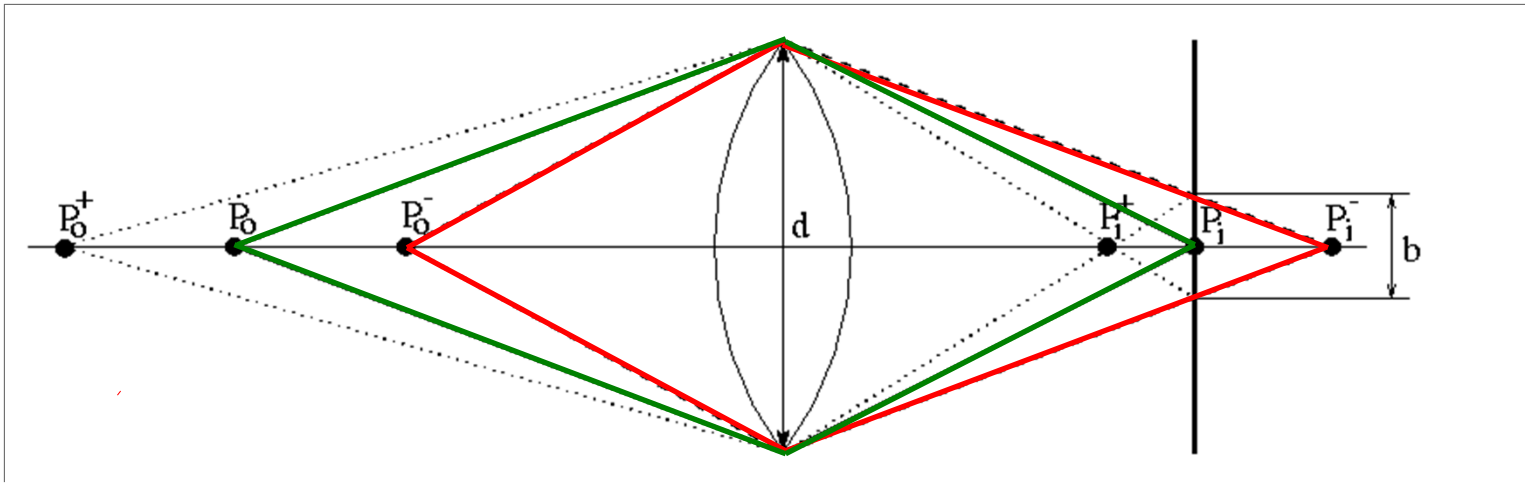


$$\Delta Z_0^- = Z_0 - Z_0^- = \frac{Z_0(Z_0 - f)}{Z_0 + f\ d/b - f}$$

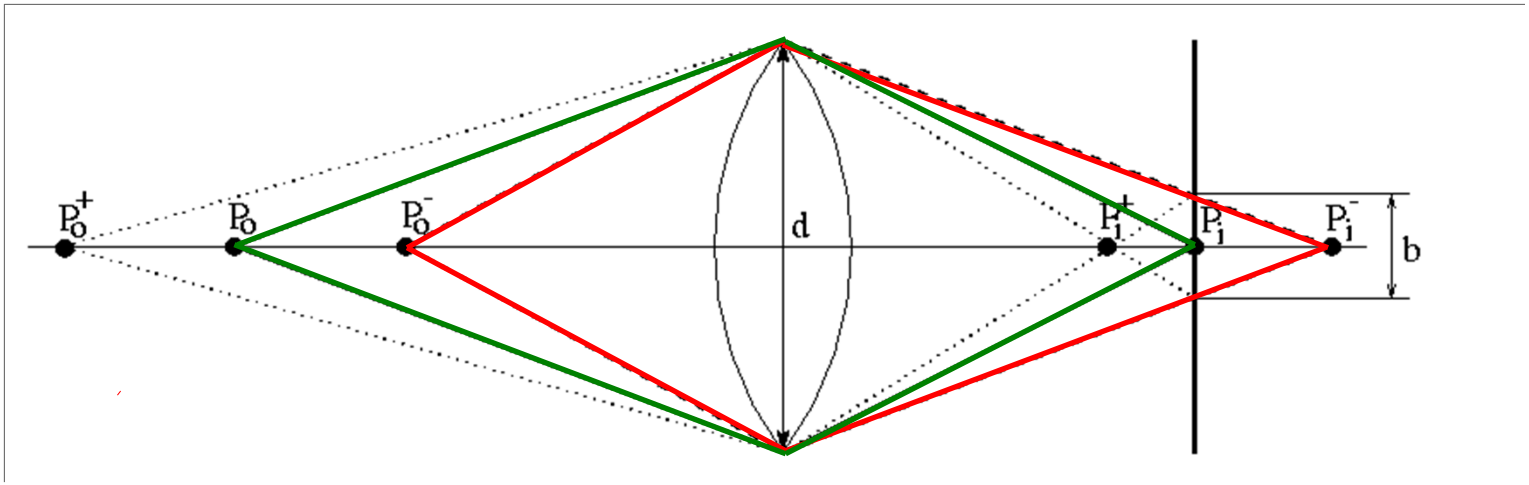
The depth-of-field



$$\Delta Z_0^- = Z_0 - Z_0^- = \frac{Z_0(Z_0 - f)}{Z_0 + f\ d/b - f}$$

decreases with d+, increases with Z_0+

The depth-of-field



$$\Delta Z_0^- = Z_0 - Z_0^- = \frac{Z_0(Z_0 - f)}{Z_0 + f\ d/b - f}$$

decreases with d+, increases with Z_0+

strike a balance between incoming light and sharp depth range