Lomo OI-10 Dark Field/Bright Field Condenser

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Introduction

Having struggled with cutting out circular masks to insert into the filter holder to make my Abbe condenser into a dark field device (with some limited success), I acquired a Lomo OI-10, with hopes of even better results. Unfortunately, without an instruction manual/guide, I have had to resort to some basic optical investigations to find out just how it works and where it might fit beyond what Lomo said many years ago.

This clever condenser can function as either a bright field (Abbe-type) condenser or as a paraboloid dark field condenser, but only by employing two separate optical systems. To succeed requires a good Kohler-type light source that will produce a source that is eventually parallel light beams up the OI-10 condenser, plus some careful adjustment of the position of the condenser with respect to the specimen on the microscope slide that one wants to see.

This article describes the light ray paths through the two parts of the condenser: when it has been set up for bright field observation and separately, for dark field observation. While several adjustments have to be made, if the distance to the slide can be set for bright field setup, it should be appropriate (or very close) for that required to use the dark field. The bright field distance setup will be covered first since it is slightly simpler to do. Figure 1 shows a photo of the OI-10 assembled and Figure 2 in two parts. Note the top part has both a central lens (for bright field) and an outer circle that appears both reflective and curved (dark field). The bottom part houses only the 37mm cylinder for securing it to a microscope and the swing out annular dark ring.

Figure 1. Lomo OI-10 assembled

Figure 2. Lomo OI-10 pulled apart.

Light source

The main requirement for this condenser to function is that it has a parallel light source that will feed equally well into the two concentric areas: the centre for bright field and the outer ring for dark field. This was accomplished by considerable trial and error, starting with a lens from an old developer (it has an iris) and an LED light source (see Walker, 2004). As the

diameter of the lens is only 20mm, placing the LED at the focal point produced a parallel beam of light but only 20mm in diameter, not adequate for the 30-32mm ring for dark field. So there was a need to spread the beam and refocus a wider 32mm parallel light beam concentrated on the bottom of the OI-10 condenser. To get the most light in this beam, first a small (10mm diameter), short focal length lens was mounted between the LED and the developer lens. This produced a slightly diverging beam on the condenser, but the introduction of a 40mm diameter, 13mm focal length plastic lens from a broken child's binocular generated an almost perfect beam. I anticipate that an unscratched, glass lens will do better when I can get one. How did I know I had succeeded?

The secret was a clear plastic food container with slightly milky water about 30mm deep, so that one could see the beam of light (the idea derived from Littlefield, 2007). Figure 3 shows the result of much experimentation with combinations of lenses: a reasonable parallel light beam. The lens shown here rests on a section of 35mm film canister of the appropriate length, but eventually it will rest just below the dark field mask. The results are shown diagrammatically below in the descriptions for both bright and dark field setups.

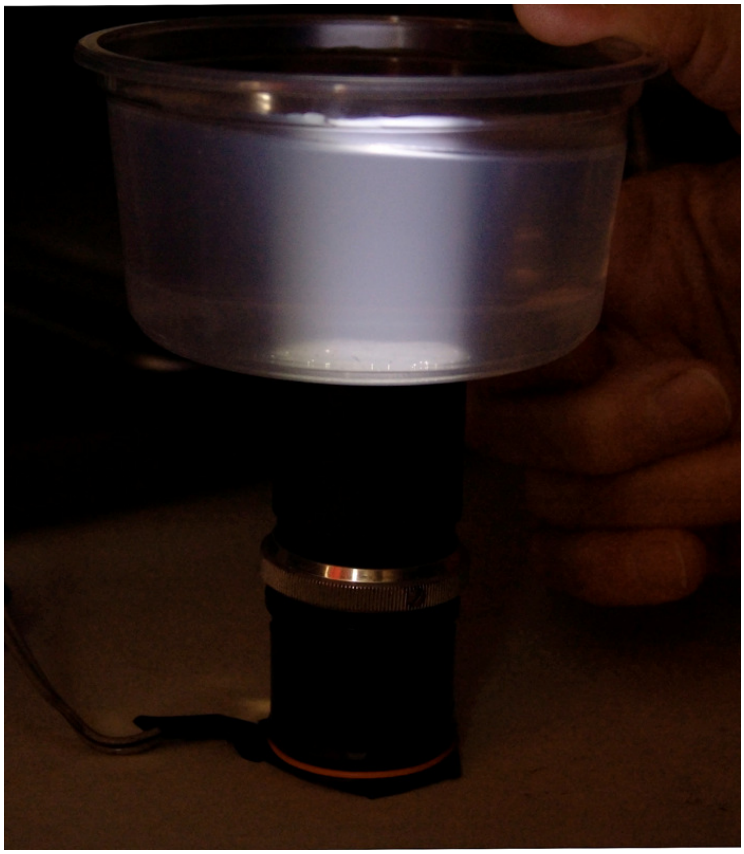

Figure 3 LED light source with lenses to produce a parallel beam of light seen in a weak milk solution in a clear plastic container.

Bright field

This setup uses only the central cylinder and the lens in the middle, functioning like an Abbe condenser. Therefore, the solid cone of light beyond the slide containing the sample should match the NA of whichever lens one is using. As usual, this is determined by the condenser iris aperture (different coloured rays only indicate different rays, *not* different coloured light).

The iris is best closed to at least the size of the inner cylinder and adjusted for the aperture value of the objective lens in order to match the cone of light, minimising stray light and maximising the light intensity reaching the objective. Figure 4 shows the cross section of this inner part of the device as it performs as an Abbe condenser, producing a "solid cone" of light with its focal point on the specimen.

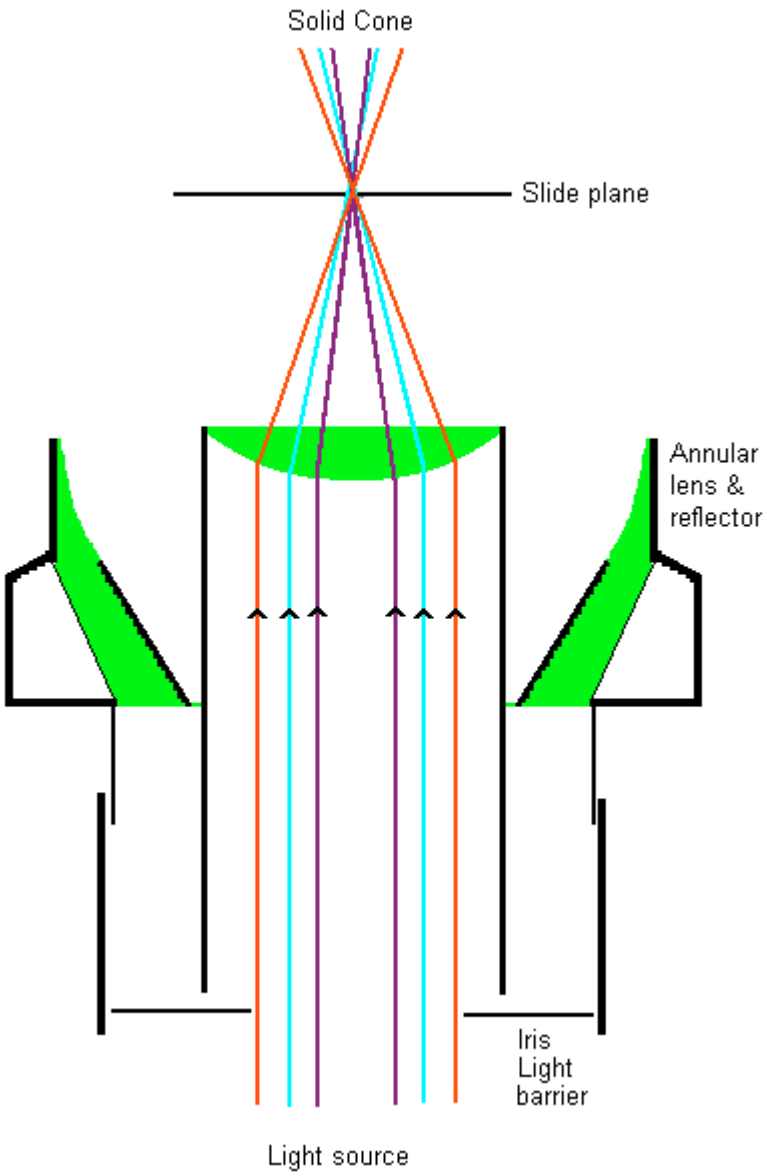

Figure 4. Bright field (Abbe condenser) configuration

Dark field

Figure 5 shows the cross section and light rays for this, generating a "cone shell" of light such that the focal point strikes the specimen on the slide and light diffracted by it is seen by the objective against a black background , since there is no direct light from the Abbe portion reaching the objective. For this, the iris must be fully opened and the annular ring swung across the cavity to block any light (labelled "Light barrier") from the source that might go into the central (Abbe) part of the device. The light rays are diverted round the centre and reflected to the focal point by what appears to be an annular lens and reflector (I have *not* disassembled this in fear of destroying it and it may be one piece of glass, e.g., a ring prism with a curved surface, so this is a best-guess inference as to the light paths. See Davidson, 2003,
in particular Figure 5b.)

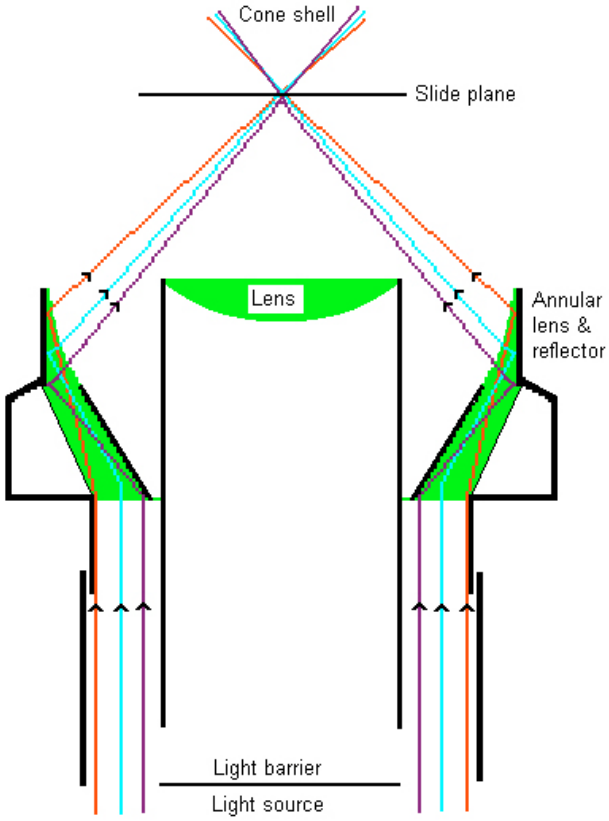

Figure 5. Dark field configuration

Visual Confirmation

Internet bloggers often complain about non-functioning condensers. The important question is, how do you know when you have a condenser set up properly? It is actually quite simple, all you need is a clear plastic container with about 10mm of weakly diluted milk in water, as above for the light source, but shallow enough to fit on the stage under the lenses. Set it on the microscope stage and look for the appropriate pattern. For bright field, you aim to have a solid cone of light emanating from where the sample on the slide would be (Figure 6). The size of the cone will ultimately be adjusted to match the NA of the objective lens using the iris in the condenser. The OI-10 supposedly is adaptable to NA up to 0.70 for bright field For dark field, one should observe a hollow cone or shell, again with the peak of the cone where the sample would be on a slide (Figure 7). For the OI-10, the distance from the top of the Abbe lens and the stage is about 11mm, and *not* almost in contact with the slide itself as with single function condensers. Being dual function, this condenser is "dry" with no possibility of water or oil link with the slide. (Note: Both photos were produced to highlight the solid and hollow tops of the cones by floating a tiny amount of gloss paint diluted with white spirit on the surface. You should be able to see the effects in Figures 6 and 7 without having to do this.) A similar approach should apply to any condenser, bright or dark field.

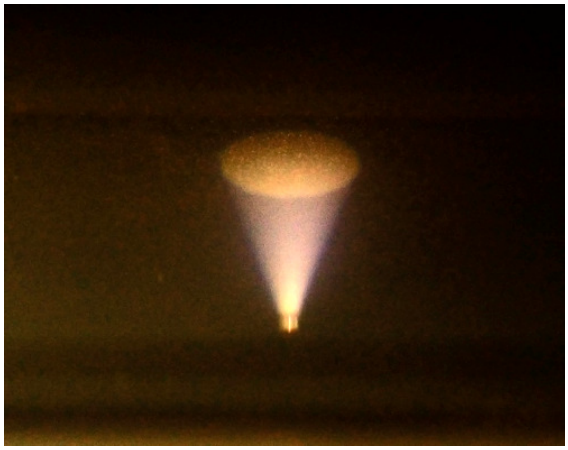

Figure 6. Light field solid light cone

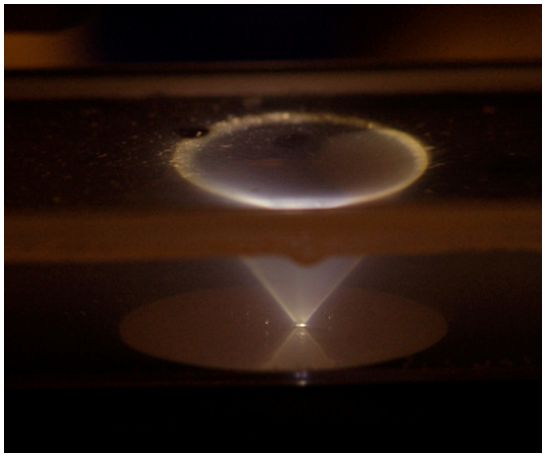

Figure 7. Dark field cone shell

A simpler and less messy way to set up and centre a dark field condenser and light source is to use a thick piece of translucent/frosted plastic or glass from you usual box of junk. If you set your piece of plastic over the hole you should see a point of light (possibly with a halo) where it is focused in the specimen, as seen in Figure 8.

If the dark field is properly aligned (i.e., parallel light from light source shines up the condenser outer tube with the mask in place), you should see a growing ring as you raise the plastic, as it was for 5mm in Figure 9, but you will probably have to shift bits about to achieve a reasonable homogeneous ring. This may not be trivial as I spent considerable time trying to balance combinations of lenses around an old developer lens (see Walker, 2004) to get a near-perfect column of light for the dark field setup. In fact the bright field setup did not seem to be so demanding and one lens was removed to improve the final images. I confess this has left me confused, but as a retired physics teacher, I refuse to be beaten and will persevere to perfect the system.

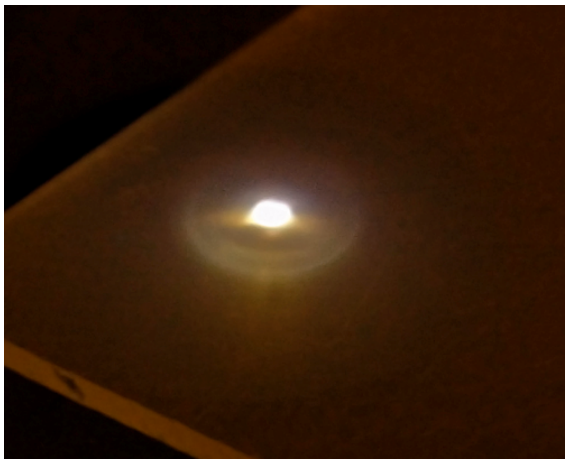

Figure 8. Frosted plastic sitting *on* stage for dark field

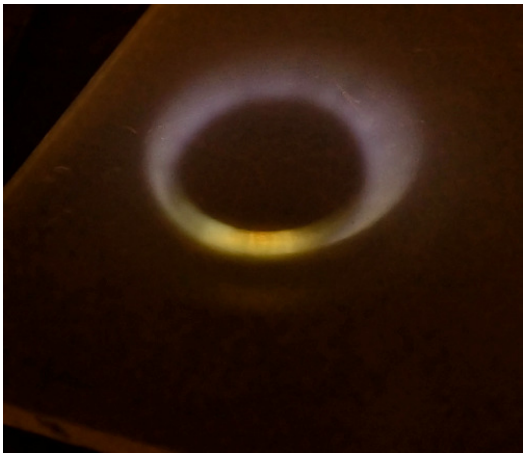

Figure 9. Plastic raised 5mm *above* stage for dark field.

Consequences of the Novel Condenser

Combining two different configurations in one device is clever, but has its consequences. Single function devices will have a larger range of apertures to accommodate with the iris adjustment (e.g., up to NA 1.2), while the OI-10 accommodates up to NA 0.7 for dark field and NA 0.6 for brightfield (see Zenith Biolam, c.1970). While this might seem to be a limitation, much amateur dark field investigation is done on rather larger specimens, like water critters, where a 20x NA 0.40 achromatic or 20x NA 0.65 apochromatic objectives (or smaller) are ideal. It will also accommodate a 40x NA 0.65 achromatic objective, though either the 40x NA 0.95 apochromatic (desired but not possessed) or 90x NA 1.25 oil-immersion objective would present problems a dedicated dark field condenser would supposedly accommodate.

A second limitation suggested by old Zenith/Lomo literature (1970, 1980) is that the OI-10 is *only* suitable for R-series with round rotating circular stages (e.g., R-10, R-11 and subsequent R-21 and R-23 among others). The only apparent difference between these and the corresponding S-series is the S-series has a square, non-rotating stage, the only advantage I have ever seen stated was to facilitate framing shots for photography. Since the camera, an inexpensive 5 megapixel one for microscopes produced by Celeron, can be rotated in the tube easily to adjust for posing subjects, there seems to be no reason not to use a fixed stage. Therefore I acquired (almost by chance) a square S-series stage having ascertained that the large central holes were adequate diameter (they were not for my basic MBY-4, since the top requires a 40mm hole and the MBY-4 was only 39mm. Machining it out 1mm seemed a bit drastic. While waiting for an adjustable R- or S-series condenser holder to appear on the market, I have epoxyed in three nuts and am using the condenser holder from the original stage, a bit fiddley to say the least, but it has allowed me to begin to explore the two approaches for samples without having to change condensers, only needing to swing the mask disk and adjust the iris to switch between light field and dark field, the main advantage of this condenser.

Sample photos

Figures 10 to 13 are some paired samples of hairs in a lacewing's wing to show the difference: One bright field and one dark field of same sample is shown using a Lomo 20x NA 0.65 apochromatic and 40x NA 0.65 achromatic objective. The dark field images are hardly perfect and do illustrate one criticism of dark field: it may have less resolution than bright field. The upside has been that I was compelled to improve my light source, the bright field photos are the sharpest I have ever produced.

Footnote

It is essential to be able to move the light source around below the condenser to ensure it is centred on it so the parallel light beam goes straight up, particlarly for the dark field. Looking under the condenser, it should be possible to see if the disc of light encompasses the entire open ring on the mask. Moving it off-centre seems to be equivalent to a half-circle mask seen in some articles, illuminating the subject from only one side, though this might be achievable with a proper condenser holder. There is much more with which to experiment here!

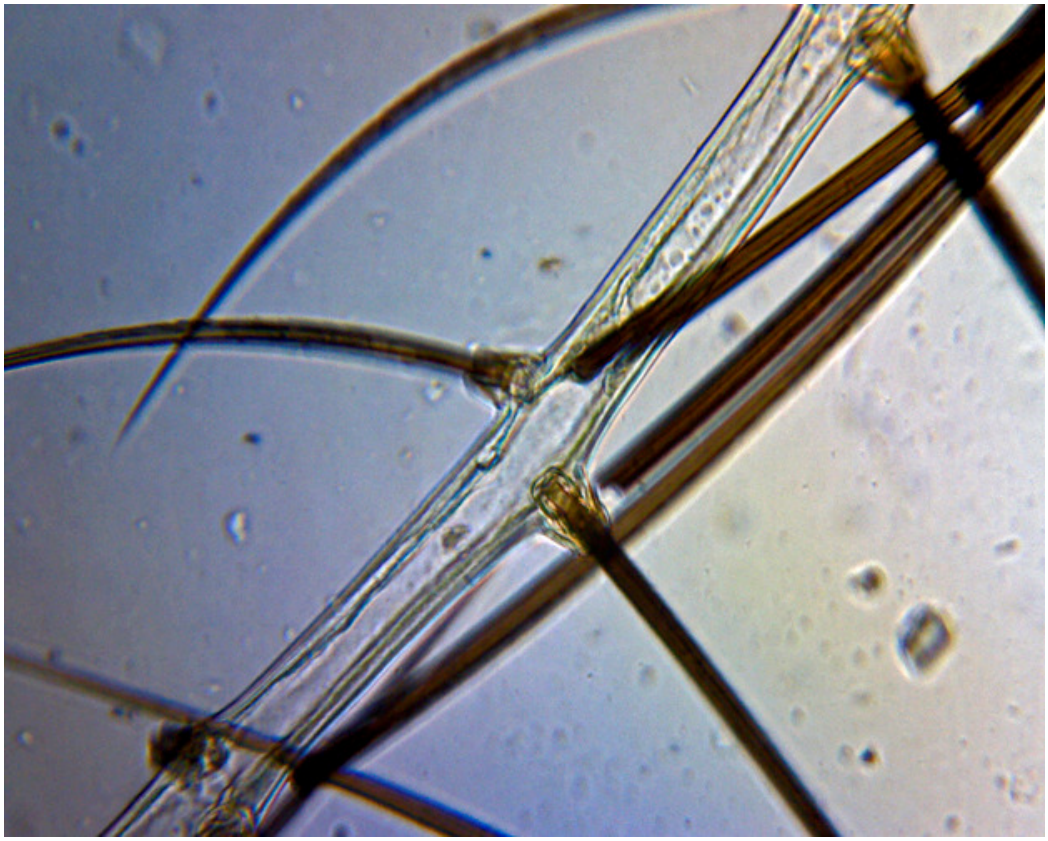

Figure 10. Bright field using a 20x NA 0.65 apochromatic objective

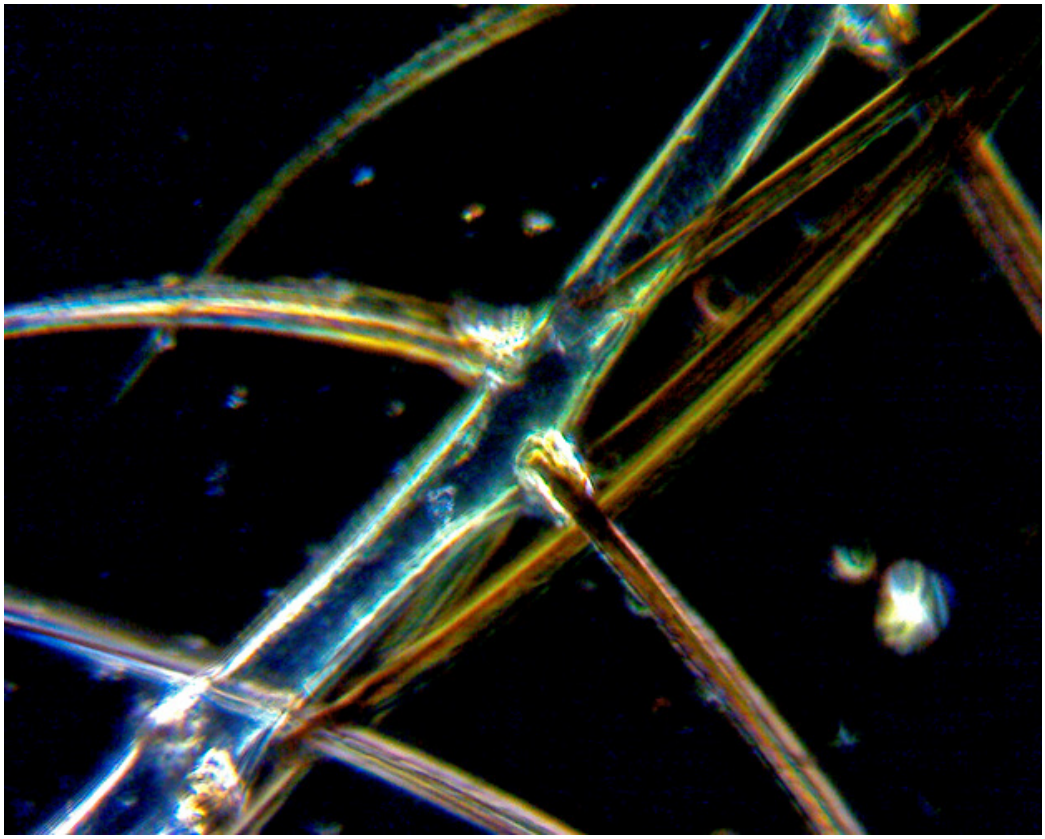

Figure 11. Dark field using a 20x NA 0.65 apochromatic objective

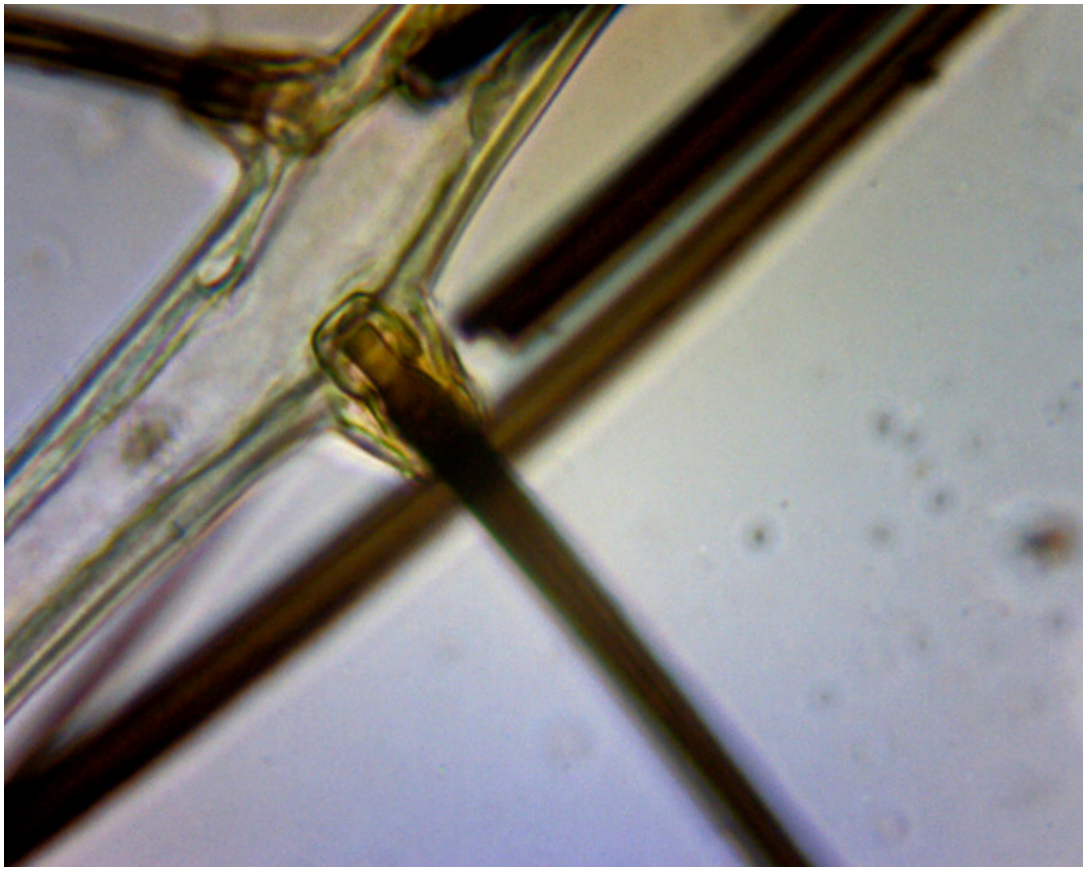

Figure 12. Bright field using a 40x NA 0.65 achromatic objective

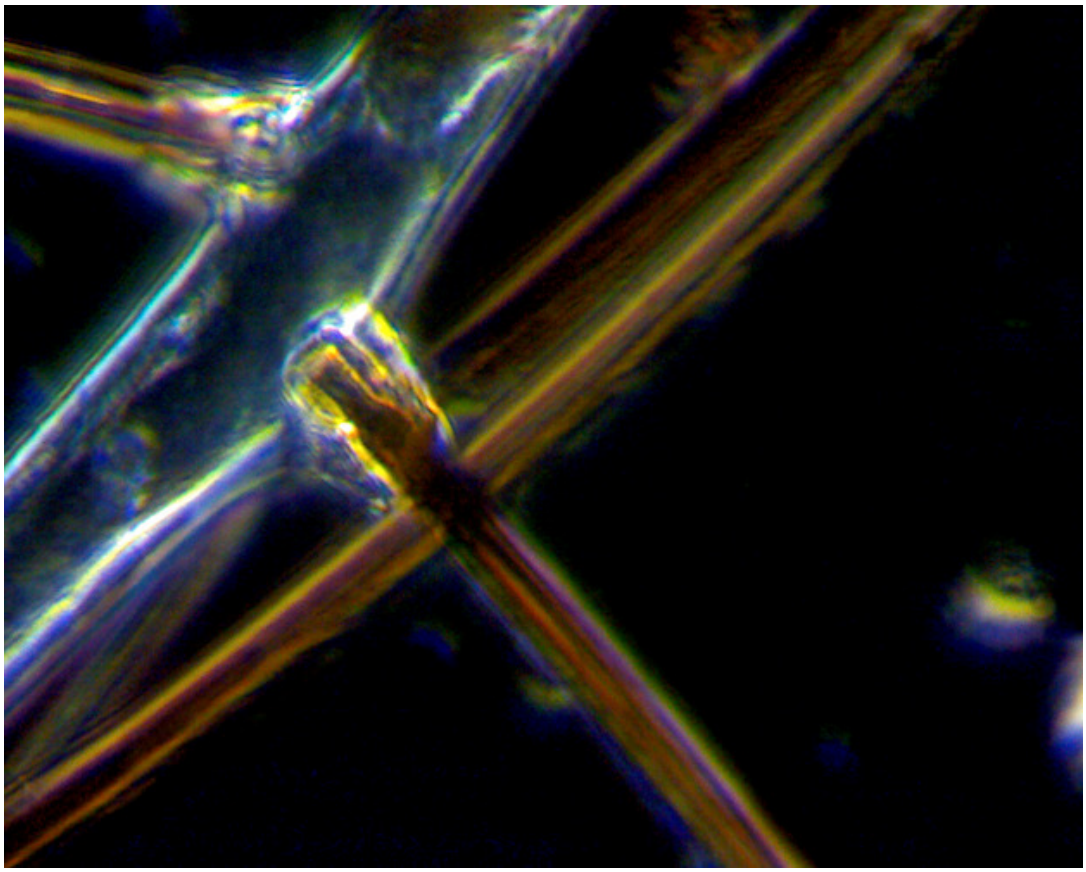

Figure 13. Dark field using a 40x NA 0.65 achromatic objective

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