Optica Software ™

ADDRESSING THE OPTICAL DESIGN AND ANALYSIS NEEDS OF CORPORATE, BUSINESS, EDUCATIONAL, GOVERNMENTAL AND INDIVIDUAL USERS.

User Miguel Alsonso, University of Rochester with our developer Donald Barnhart at Frontiers in Optics 2005 in Tucson, Arizona.

Optica Software News

Season of giving sale!

Buy our Optica Software packages for the optical designer in your life. We are offering a **10%** discount on **ORDERS PLACED ONLINE** until December 31, 2005. To qualify you can simply log on to our website at: www.opticasoftware.com/store and the prices are already discounted.

As our way of giving back to you, each order placed on our website through **December 31, 2005,** will qualify to receive a $25 gift card for Amazon.com (two orders = two gift cards).

Our online survey recipient for November 2005 is **Aaron Turner,** of the **Goodrich Corporation**. Please continue to fill out the survey for your chance to win. For more details visit our homepage at: www.opticasoftware.com.

We are currently seeking international resellers. Contact us at: support@opticasoftware.com to request a copy of our reseller application.

LensLab Manual on the Web!

Please take a look at our support page at: http://www.opticasoftware.com/support/ to view the new *LensLab*™ manual. All of the features included in *LensLab*™ are also included in *Rayica*™, so using the manual can be useful to beginning *Rayica*™ users also as it contains numerous examples. The manual includes an introduction, overview and reference guide and nine chapters to get you started:

Basic Features of *LensLab*
How *LensLab* Does Ray Tracing
Tour of Component Functions
Positioning Functions
Advanced Features of *LensLab*
Experimenting with *LensLab*
Designing with *LensLab*
The Anatomy of Ray
The Anatomy of Component

Online Shopping

You may order through our online store with ease and convenience. Our website is very secure and purchases made through our website are protected by Verisign. Shopping online offers many benefits and is no less safe than shopping in a store or doing business by mail. The internet is open 24 hours a day, seven days a week. Visit our online store at: www.opticasoftware.com/store to keep up to date with the latest changes concerning our software development. You will also find answers to many of your technical questions through our online support and documentation: http://www.opticasoftware.com/support/.

1

Notes from the Developer

Donald Barnhart, Ph.D. – Optica Software Lead Developer
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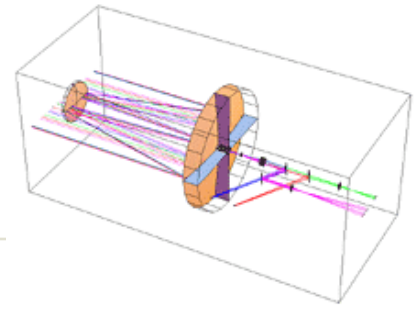
Calculation of Numerical Aperture for Unconventional Light Collection Geometries

The numerical aperture is a useful figure of merit for defining the ability of an optical system to collect light from a point source. In axially symmetric optical systems, the numerical aperture **NA** is defined as **NA = n Sin[theta]**, where **n** is the refractive index of the collection environment and **theta** is the half angle of the input light collection cone. As such, in low refractive environments such as air, the **NA** can never significantly exceed the value of 1. However, in high refractive environments, such as in oil immersion microscopy, it becomes possible for the **NA** to be greater than unity.

In diffraction-limited imaging systems, the numerical aperture of the system generally determines the maximum resolving power of the system. As such cases, a higher **NA** value would correspond with a greater resolving power. In the case of imaging microscopy, typical microscope objectives can have **NA** values that range from 0.1 to > 1 (usually increasing with the magnification). Ironically, in the case of imaging systems, while the **NA** may determine the resolving power of the optic, it does not necessarily indicate the ability of the system to the efficiently transfer energy from the collected source to a detector. This is because the need for diffraction-limited performance can result in higher system complexity with many cascaded lens elements. While the system may capture rays from large collection angles (resulting in a high **NA**), the high internal complexity may be less efficient in transmitting the available collected light. In addition, higher magnification systems will have correspondingly smaller fields of views and this places a natural limit on the amount of scattered light that can be collected. Therefore, one must be careful in interpreting how the **NA** of a system relates to its performance.

In non-imaging applications designed for high light-collection, the **NA** is also a useful figure of merit. This time, however, the system's resolving power is less important than the ability of the system to effectively capture and transmit the available light from a source to a detector. In such an instance, the light-collection optics may not be a traditional axially-symmetric lens train or have diffraction-limited performance. In some cases, non-circular components, reflective, or even an array of elements may be employed. With such unconventional geometries, it becomes very difficult to analytically calculate an effective numerical aperture for the system. For this reason, I have recently developed a ray-trace method to calculate the effective **NA** as it relates to the light collection ability of a system (rather than resolving power ability).

My approach compares the number of rays that pass through a collection system with that from a reference system of known numeric aperture. By the using the ratio of the ray count from the collection optic with the ray count from the reference system, the effective numeric aperture of the collection optic is then determined by a simple relation. In particular, in the case where the reference system has a numeric aperture of 0.707, then the effective numeric aperture of the collection optic is given by:

NA = Sqrt[r/(1+r)] (1)

where r = (collection optic ray count)/ (reference ray count).

As an example, one possible axial-symmetric reference optic with **NA = 0.707** is given by the following model:

referencesystem = {PointOfRays[{20,20}, NumberOfRays->101, BirthPoint->{-10,0,0}], Screen[20]}

In this case, the **PointOfRays** function creates a point source of rays that emit from the **BirthPoint** position at **{x,y,z} = {-10,0,0}** and are projected through a square region at the origin of the ray-trace coordinate system, whose sides have a length of 20 units. In this case, the **BirthPoint** option creates a uniform rectangular distribution of rays at the y-z plane crossing. Finally, a circular screen is placed in the y-z plane at the origin with a diameter of 20 units. The ray-trace and reference ray count is now accomplished with **TurboTrace** and **ReadRays**.

referencecount = Length[ReadRays[TurboTrace[referencesystem], OpticalLength]];

Here **TurboTrace** only reports the rays that fall within the circular screen aperture and **Length[ReadRays[..]]** is used to obtain a ray count at the reference surface. In particular, a count of the **OpticalLength** parameter values indicates the number of rays present in the trace. In a similar fashion, a collection optic can then be traced with the same light source and the number of rays delivered through the collection system can then be counted. Once this is accomplished, the numeric aperture of the collection optic is directly given by equation (1) using the ratio of the collection system count to the **referencecount**.

You can see more examples and derivation of equation (1) by visiting the support area of our website: www.opticasoftware.com/support/

Photos
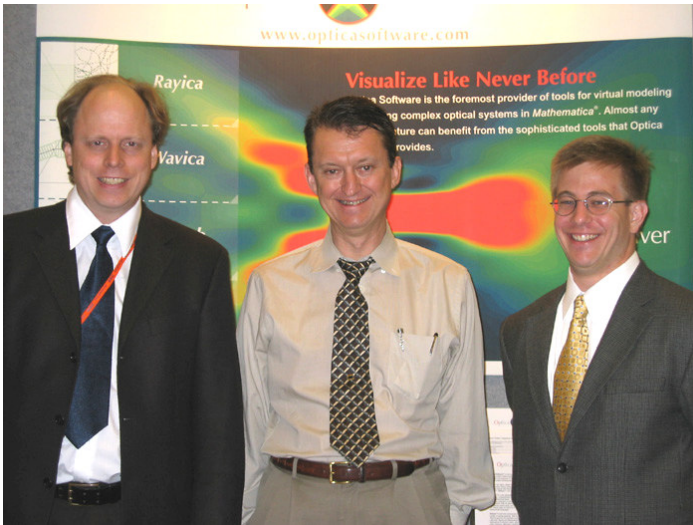
Attending Frontiers in Optics 2005 are Donald Barnhart (left) Frontiers in Optics Conference Co-Chair and *Mathematica* enthusiast Russell Chipman, University of Arizona, (middle) and Jeremy Hatcher (right) a software engineer from our corporate office.

(Below) This picture was taken at our corporate open house on Thursday, November 10, 2005. Optica Software is a Division of iCyt Mission Technology, Inc. We have complete in-house expertise for the design and construction of optical systems, mechanical systems, electronic systems, prototype assembly, and product fabrication. As such, we offer true vertical integrated services for systems design, modeling, and manufacturing. Contact us for a full-service quote on your next project.

New Axicon Modeling Using Rayica (Submitted by user Charlie Barnes of Del Mar Photonics)

Using the new optical modeling tool Rayica, we were able to do successfully model beam propagation through two axicons with 140°
cone angles.
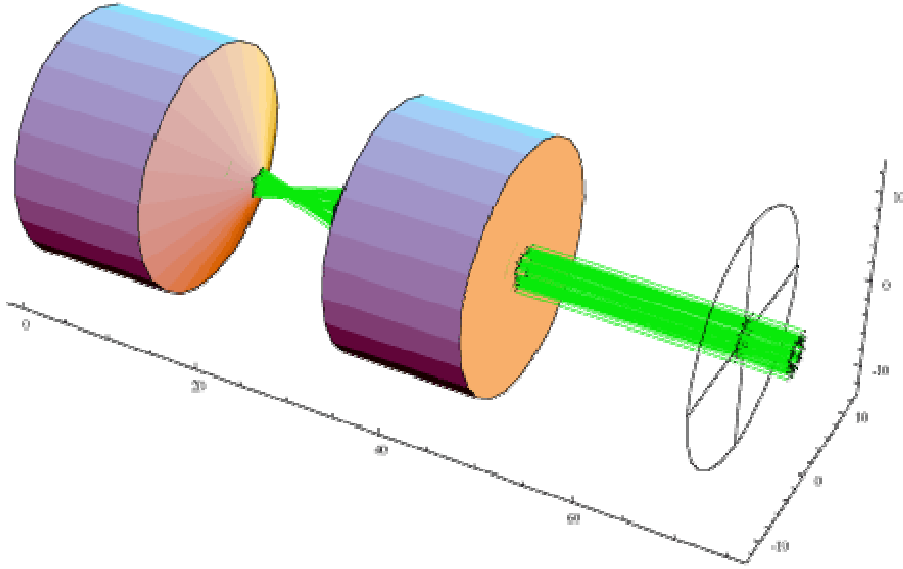
Here, two axicons, facing away from each other create a "hollow" beam. This hollow beam has numerous applications, though recently
Bing Shao at the University of California (San Diego) used the hollow beam to trap living cells with laser light.


Surface Intensity
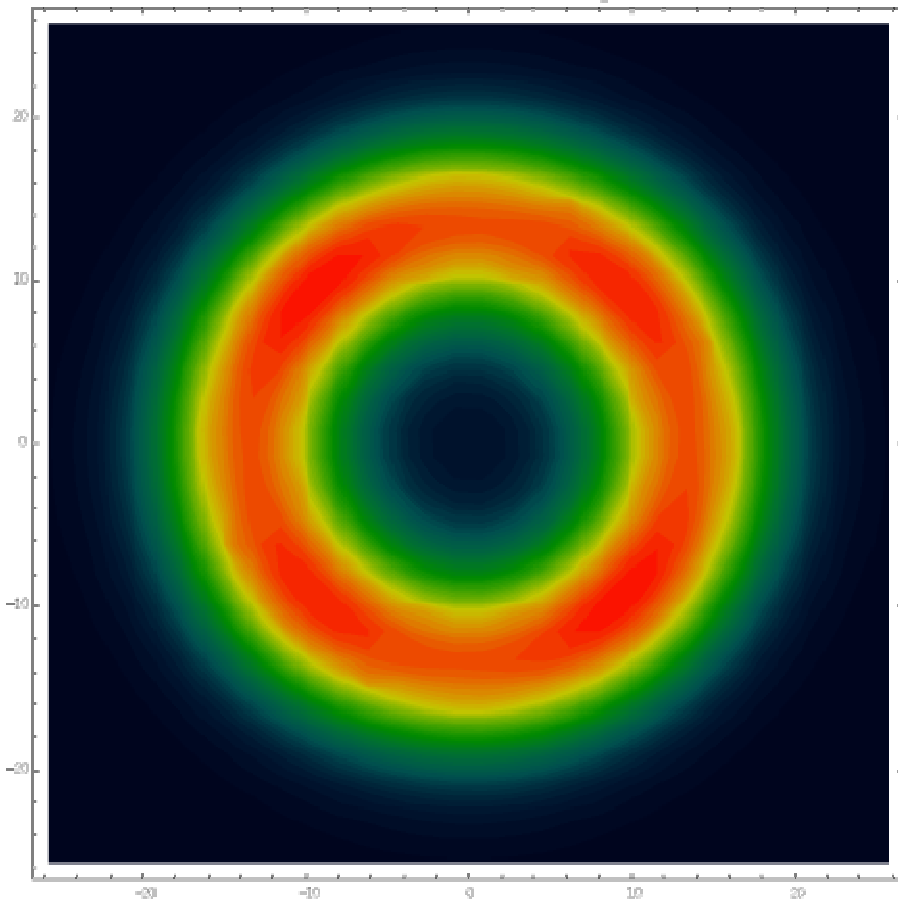
Use of IntrinsicMedium   (Submitted by user Andy McKie from Raytheon)

When performing calculations in *Rayica*™ and *Wavica*™, use **IntrinsicMedium→Vacuum** to compare results with those calculated by common formulae where a refractive index of 1.0 is assumed.

> **sys1= DrawSystem [**
>   **{Move [SingleRay[Polarization→{1,0,0}, IntrinsicMedium→Vacuum],10],**
>   **Move [RetardationPlate[0.25,45,50,10],{50,0},0],**
>   **Boundary [100]}, PlotType→TopView];**
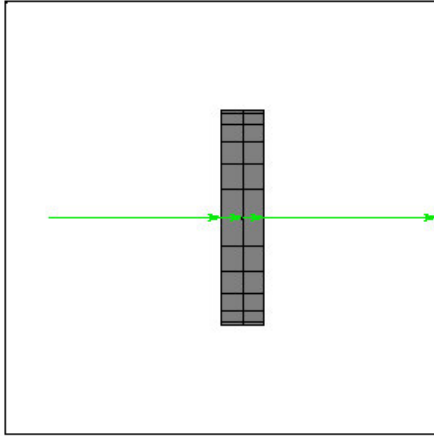
> **ReadRays[sys,{{ComponentNumber, RefractiveIndex}}]**
> **{{{1, 1.}}, {{1, 1.46075}}, {{1, 1.46075}}, {{2, 1.}}}**

If you have examples that you would like to submit to the **User Tips** section please forward them to: support@opticasoftware.com.

At the end of the day, our lead developer Donald is hard at work on the latest software upgrades.

Events

Optica Software will have space at **Photonics West**, January 24-26, 2006 in San Jose, California. The link for the exhibit can be found at: http://spie.org/app/exhibition/index.cfm?fuseaction=welcome&meeting_id=91. Please stay posted for details on a presentation by our lead developer Donald Barnhart, Ph.D.