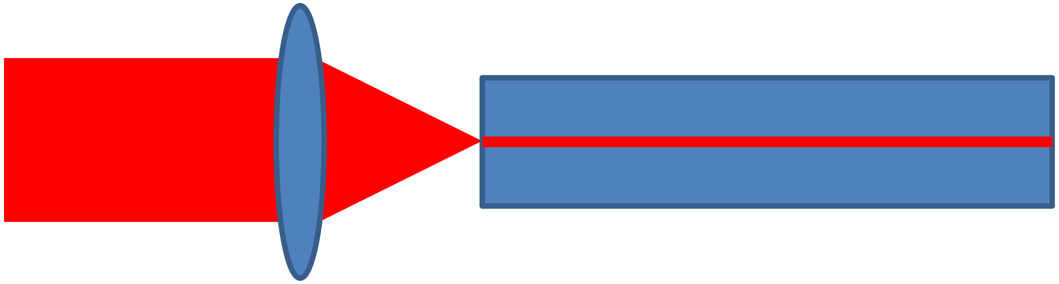
Project 5: Bending loss in optical fibers

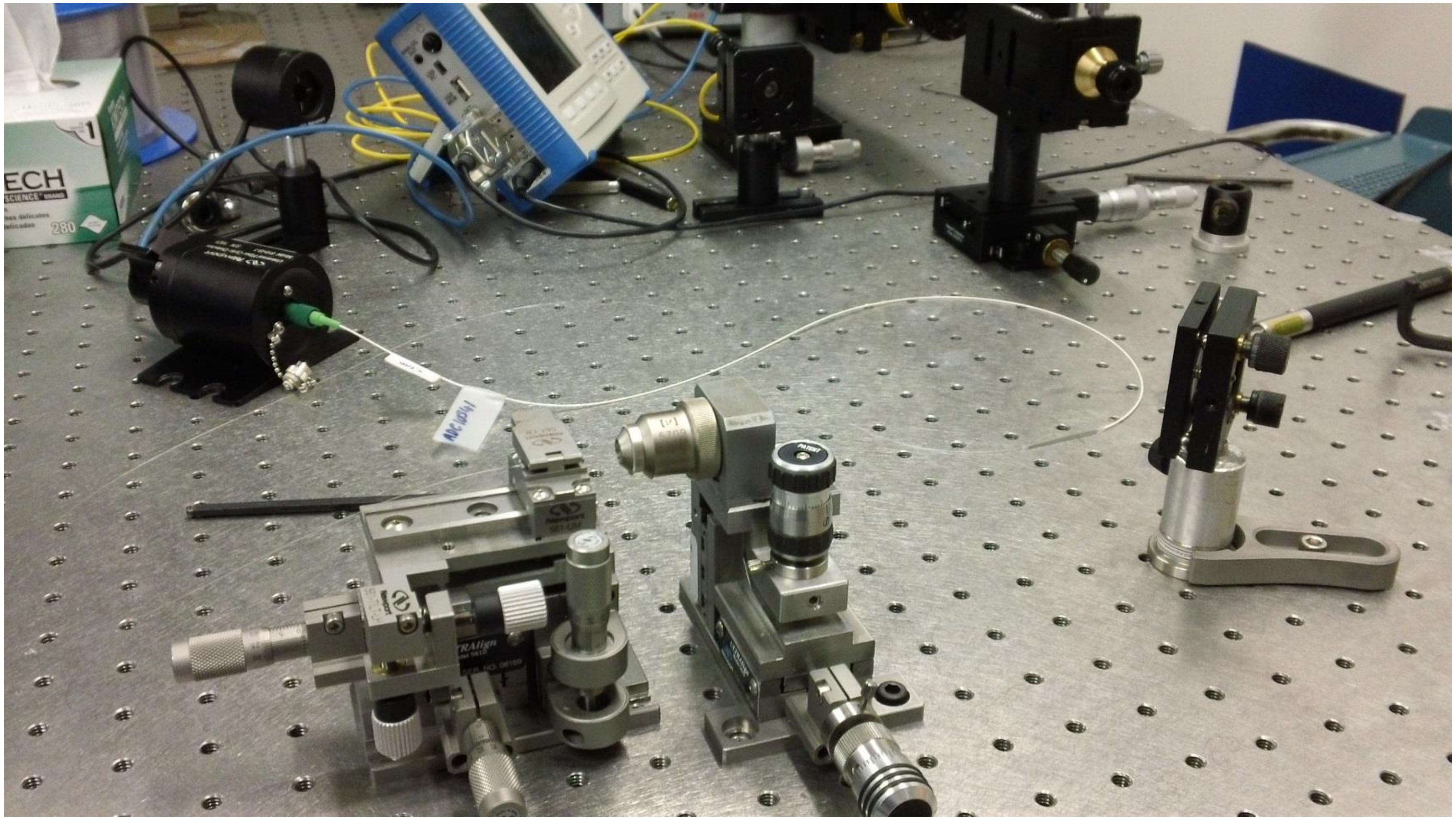
Free space coupling

Goal: learn how to couple a laser beam from free-space into a singlemode optical fiber.

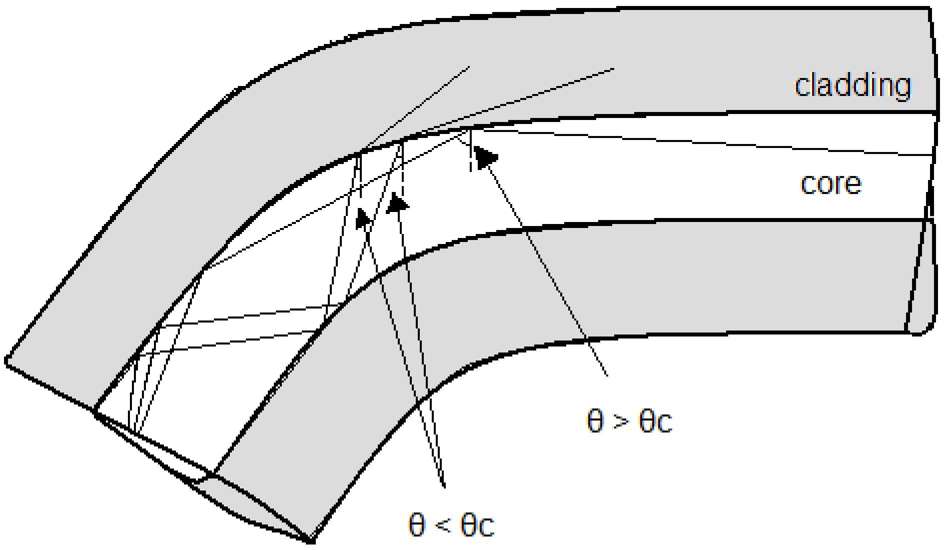
- Choose the right lens: need to match the NA and spot size to the core size of the fiber
- Perform alignment: can take a long time if you use bruce-force. Can be done very quickly with some “tricks”



Free space coupling



Bending loss



Bending loss

- Propagating modes within an optical fiber can be characterized by an electric field distribution with maxima inside the fiber core and evanescent fields that extend outside the fiber core into the cladding. Thus, some of the optical energy in the mode is actually propagating in the cladding.

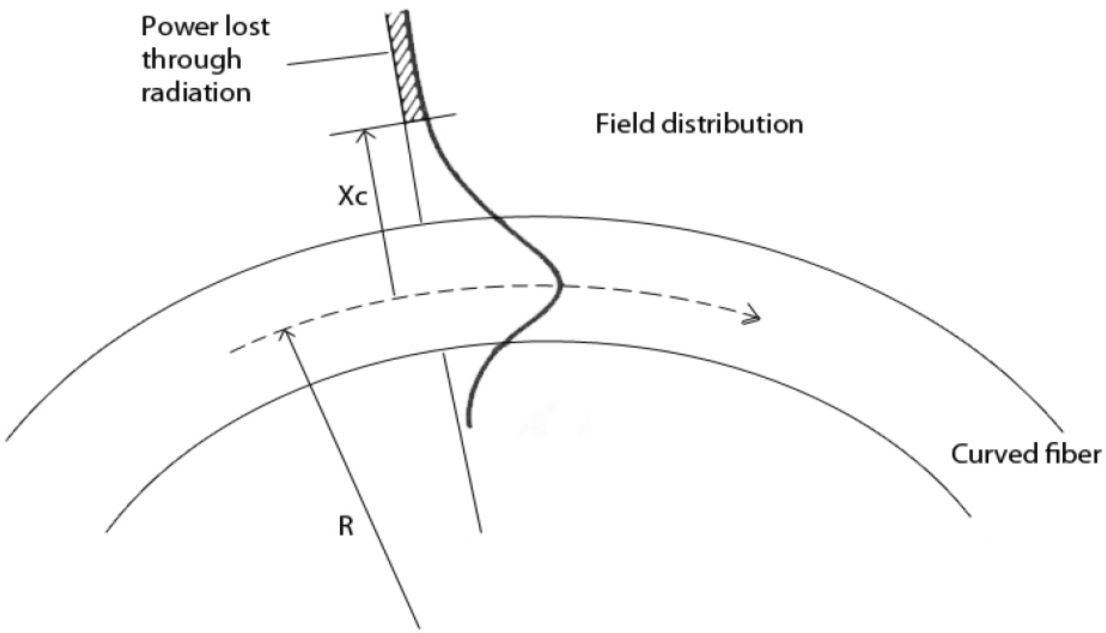


Figure 3.5: Sketch of the fundamental mode filed in a curved optical waveguide.

Micro bending loss

- Associated with microscale fluctuations in the fiber radius typically due to nonuniformity in fiber diameter arising during the fiber drawing process or in response to radial pressures.
- Random variation in the fiber geometry (and propagating mode characteristics) along the propagation direction. The result is a coupling between guided wave modes and non-guiding (leaky) modes. Careful packaging of fibers and control of draw conditions during fabrication are critical to reducing these effects.

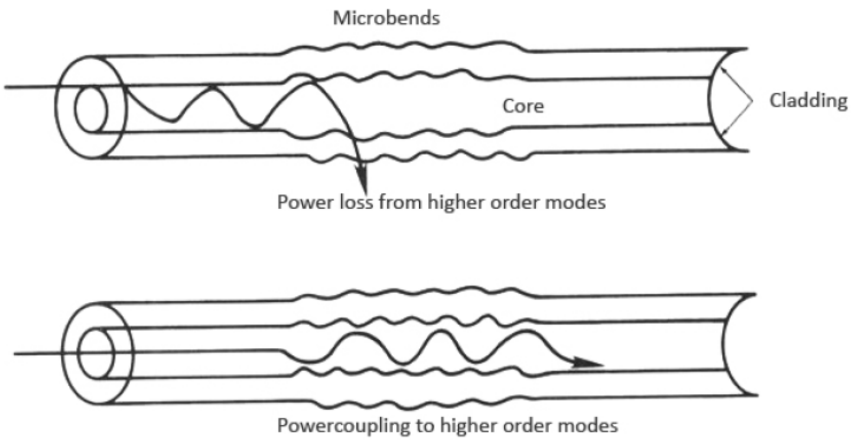
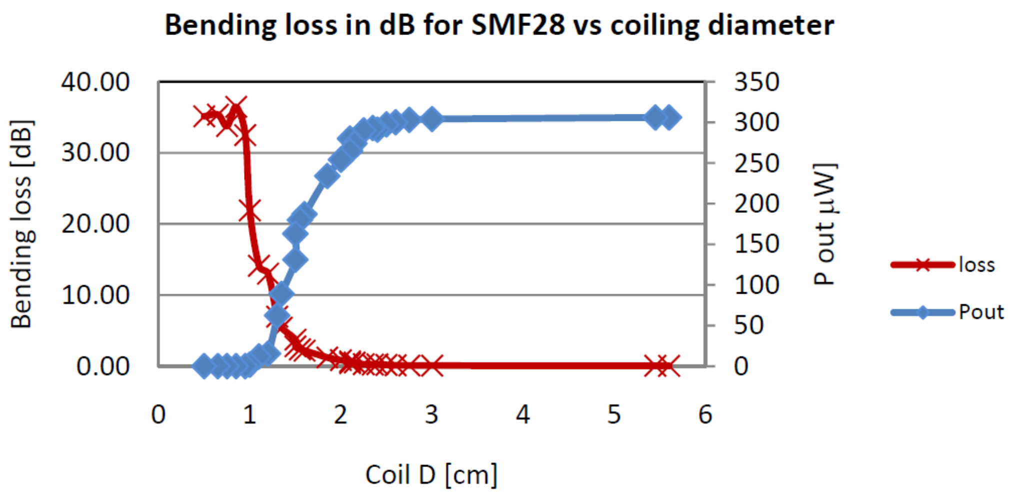
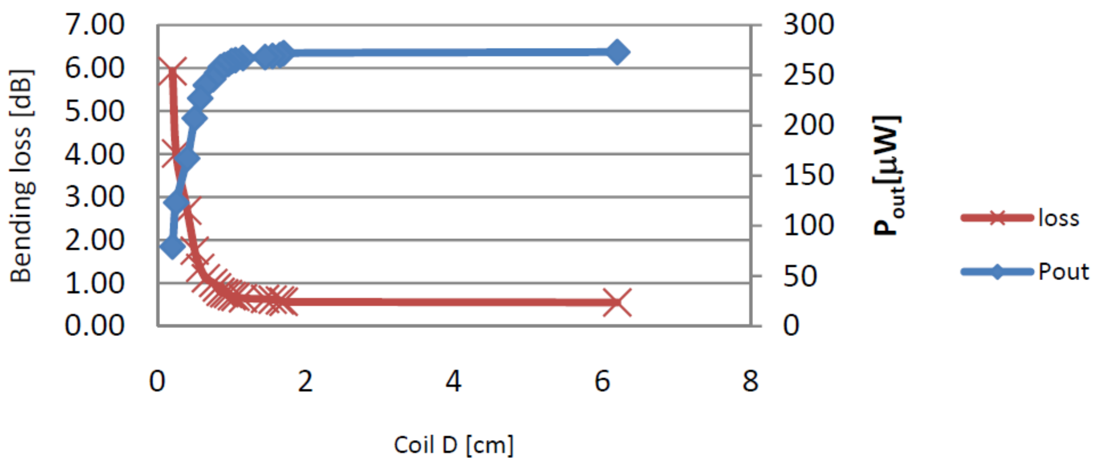


Figure 3.6: *Microbending losses arising from small-scale fluctuations in the radius of curvature of the fiber axis.*

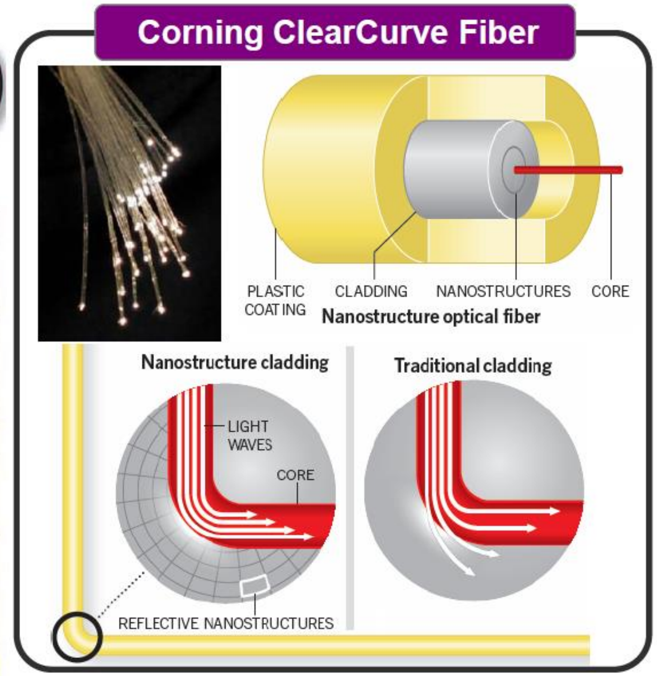
Progress in bendable fiber



Bending loss
In Corning Clearcurve
fiber



Progress in bendable fiber

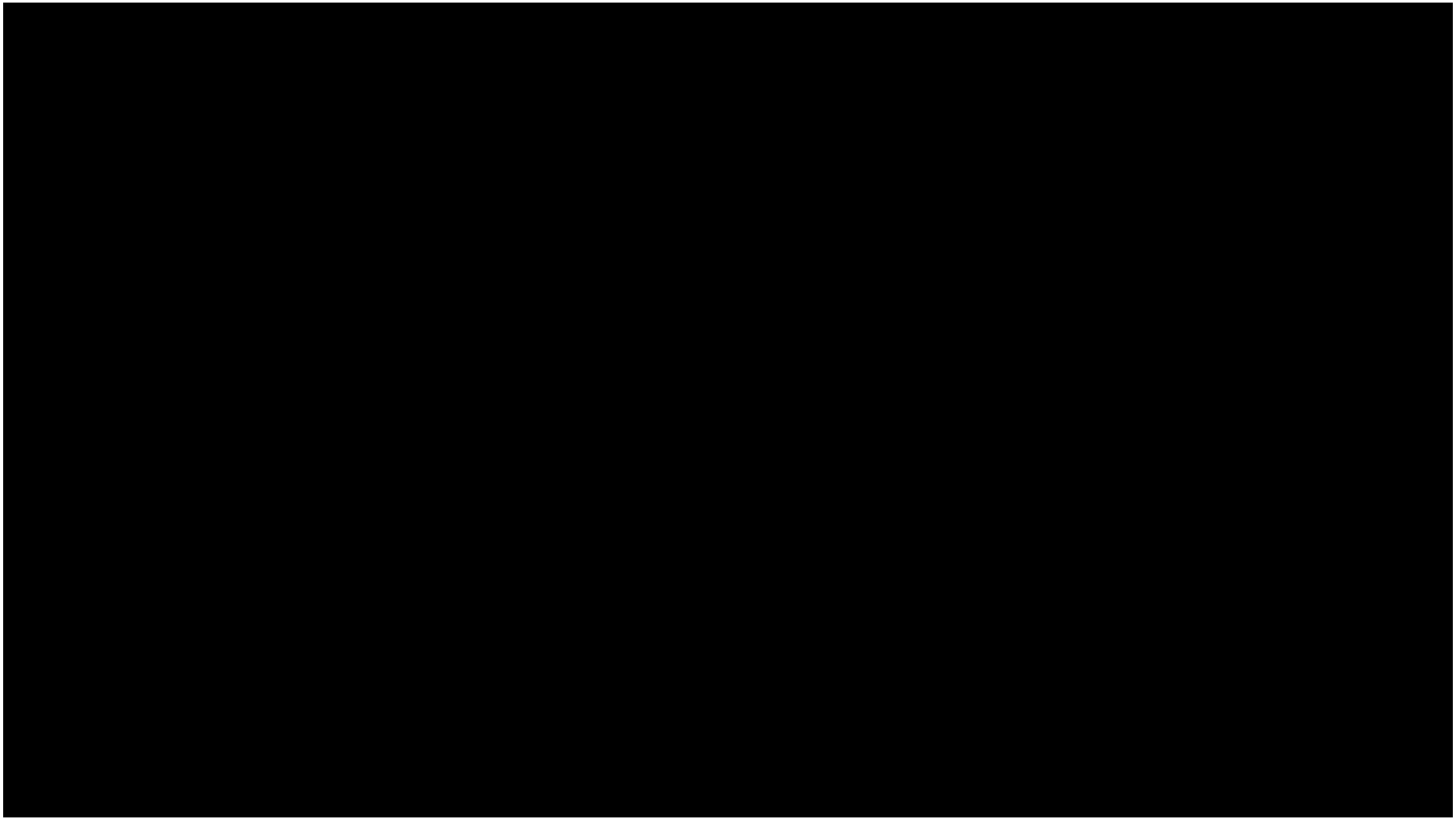


- ❑ Corning NanoStructures Technology
- ❑ Best macrobending performance
- ❑ Compatible with current optical fibers
- ❑ **Attenuation**: **0.19-0.21 dB/km (1550nm)**
- ❑ **Macrobend Loss**: **<0.10 dB (Radius: 5 mm**

Corning Incorporated

http://www.youtube.com/watch?v=1bHVguGn4hU

Progress in bendable fiber



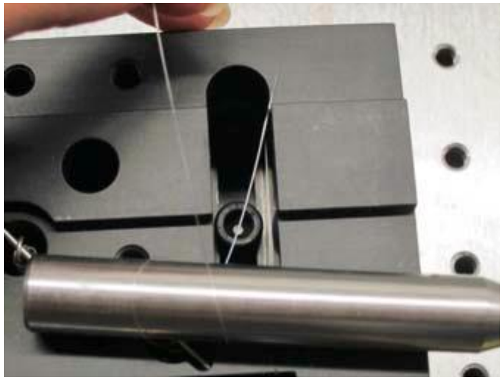
Bending loss measurement

This project will deal with bending loss measurement techniques:

- wrap on a mandrel technique
- knot technique

We will measure bending loss of a multimode fiber and a few singlemode fibers:

- standard multimode fiber (62.5/125)
- Corning SMF28, Ultrahigh NA fiber and Corning ClearCurve



Bending loss characteristics

- Loss mechanism: coupling to non-propagating modes
- Larger loss for longer wavelength
- Smaller loss for higher NA
- Critical bending radius

Bending loss calculation:

- D. Marcuse, JOSA 1976; R. Schermer, QE 2007

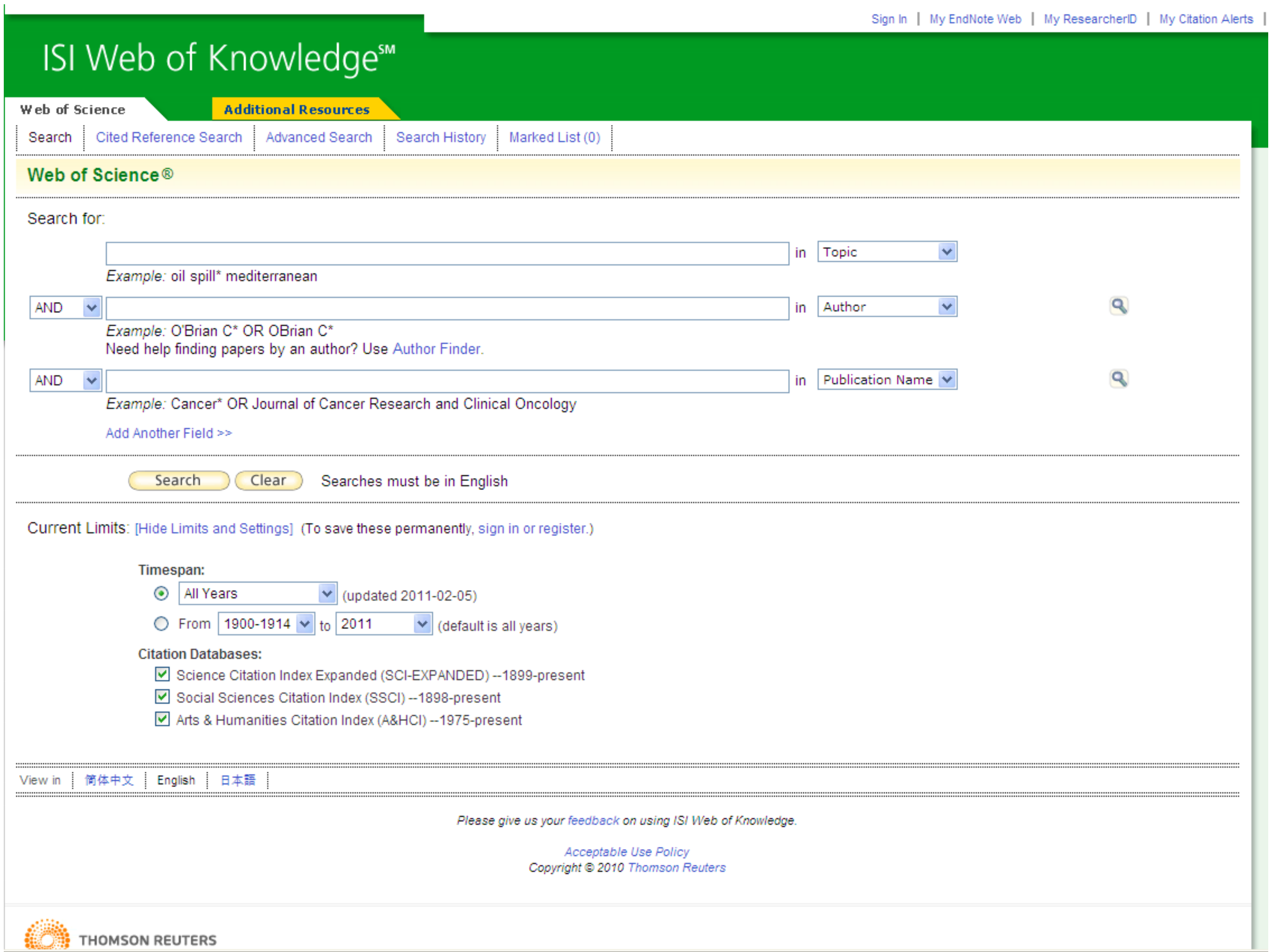
How to learn about what has been done in your field?

1. Know everything about what has been done in the field
2. Know about the remaining challenges
3. Come up with solution from time to time to solve one of the remaining challenges
4. Collaborate with experts from other fields to solve a common problem

Journals in Optics

1. Nature journals (Nature, Nature Physics, Nature Photonics), Science
2. Optical society of America (opticsinfobase.org), SPIE
   - Optics Express, Optics Letters, …
3. IEEE journals
   - PTL, JLT, QE…
4. AIP, APS journals
   - PRL, APL…
5. Other journals:
   - Optics Communications, Applied Physics B…

ISI Web of Knowledge



isiknowledge.com

Journals impact factor

ls 41 - 60 (of 71)

[1 | 2 | 3 | 4]

UPDATE MARKED LIST

Ranking is based on your journal and sort selections.

Mark	Rank	Abbreviated Journal Title *(linked to journal information)*	ISSN	JCR Data					
				Total Cites	Impact Factor	5-Year Impact Factor	Immediacy Index	Articles	Cited Half-life
☐	41	J X-RAY SCI TECHNOL	0895-3996	153	0.571	0.780	0.000	25	5.6
☐	42	LASER ENG	0898-1507	97	0.179	0.235	0.000	13	
☐	43	LASER FOCUS WORLD	1043-8092	252	0.203	0.171	0.082	73	7.4
☐	44	LASER PHOTONICS REV	1863-8880	328	5.814	5.814	2.200	35	1.6
☐	45	LASER PHYS	1054-660X	1293	0.676	0.591	0.263	346	4.5
☐	46	LEUKOS	1550-2724	54	0.500	0.557	0.278	18	
☐	47	LIGHTING RES TECHNOL	1477-1535	372	1.256		0.143	21	8.0
☐	48	MICROELECTRON ENG	0167-9317	5616	1.488	1.456	0.291	556	4.4
☐	49	MICROLITHOGR WORLD	1074-407X	21	0.188	0.195		0	
☐	50	MICROW OPT TECHN LET	0895-2477	4141	0.682	0.614	0.151	845	4.5
☐	51	NAT PHOTONICS	1749-4885	3468	22.869	23.215	5.402	82	2.0
☐	52	OPT APPL	0078-5466	165	0.358	0.297	0.020	99	4.7
☐	53	OPT COMMUN	0030-4018	14516	1.316	1.342	0.359	877	7.3
☐	54	OPT ENG	0091-3286	4863	0.553	0.658	0.083	360	9.1
☐	55	OPT EXPRESS	1094-4087	32080	3.278	3.477	0.584	2548	3.1
☐	56	OPT FIBER TECHNOL	1068-5200	465	0.939	1.063	0.224	76	6.2
☐	57	OPT LASER ENG	0143-8166	1390	1.262	1.253	0.302	192	5.2
☐	58	OPT LASER TECHNOL	0030-3992	1268	0.981	0.938	0.381	160	4.9
☐	59	OPT LETT	0146-9592	36454	3.059	3.299	0.598	1308	6.4
☐	60	OPT MATER	0925-3467	4552	1.728	1.779	0.238	361	5.0

My opinion (you don’t have to agree)

These numbers are things that we, scientists, created to entertain ourselves. They are virtual impact, in my opinion. The real impact comes from the number of lives that we have saved or improved.

Conferences in Optics

Photonics West

CLEO/QELS

ASSP

Frontier in Optics

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Questions for thoughts

- What are the techniques to reduce bending loss in optical fibers?
- What journals in optics do you read?
- What do you think would be a good metric to assess the work of a scientist?
- How does ClearCurve fiber has such a good bending loss performance?