

Microsphere Based Er³⁺ Microlasers

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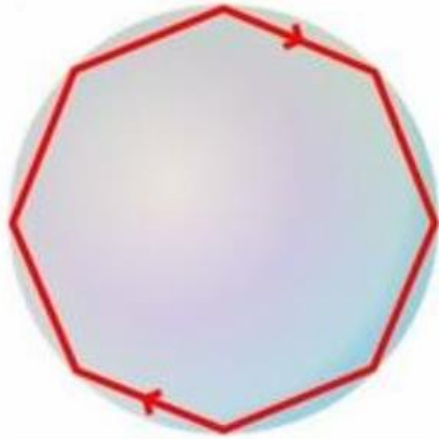
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Outline

- Spherical microresonators overview
- Coating of spherical microresonators
- Microsphere based lasers

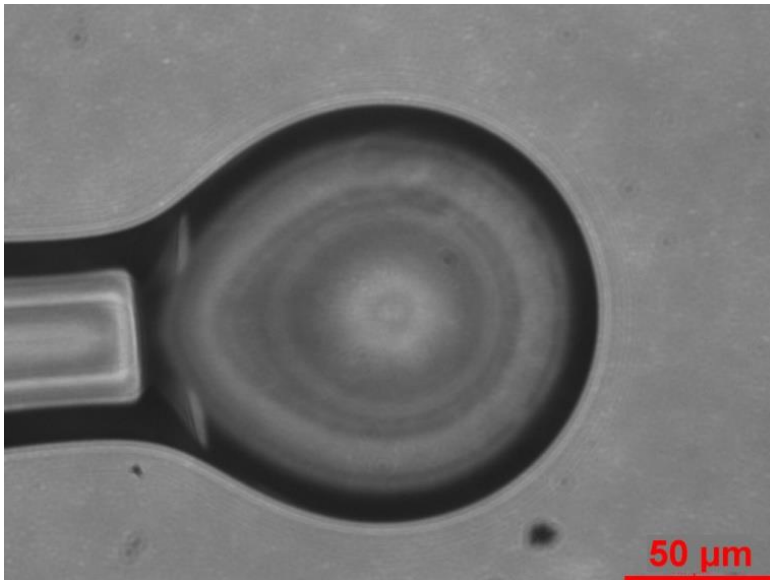
Spherical microresonators

Light confinement via total internal reflection



The modes are called
whispering gallery modes

Spherical symmetry – modes
have n, m, l

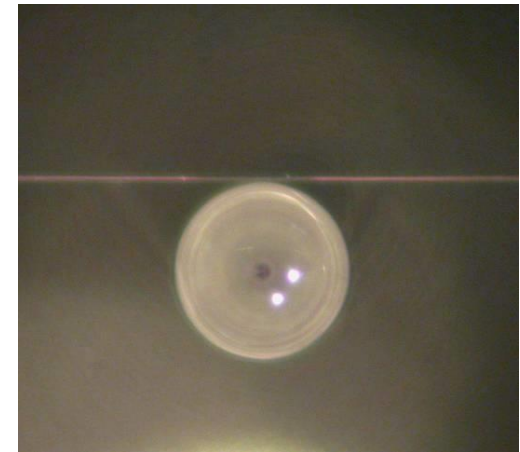
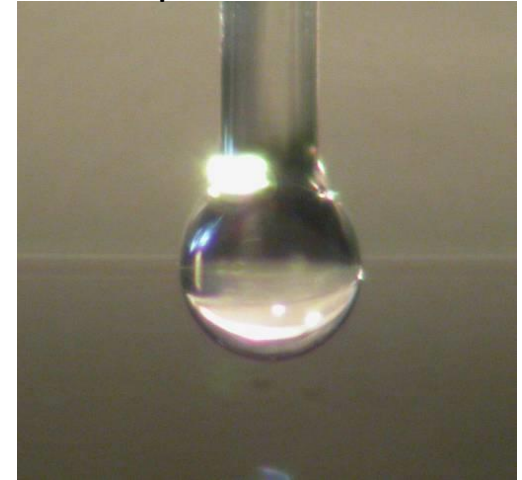


High **Q-factor** (10^6 - 10^9), Low **mode volume** (λ/n)

Coupling via a tapered fibre

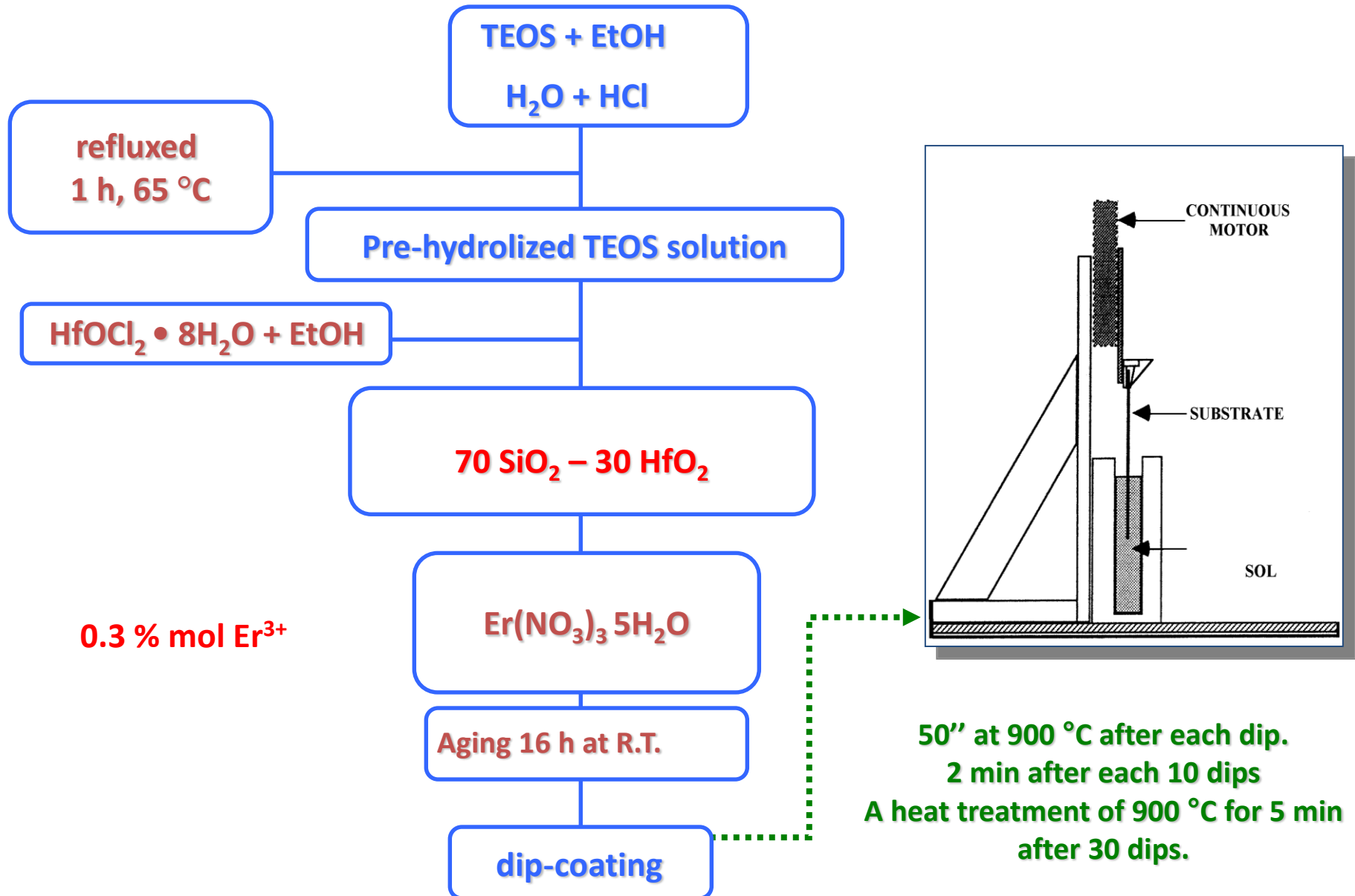
Applications:

- Non-linear optics (FWM, frequency combs)
- **Lasing**
- Sensing
- QED (single photon sources)



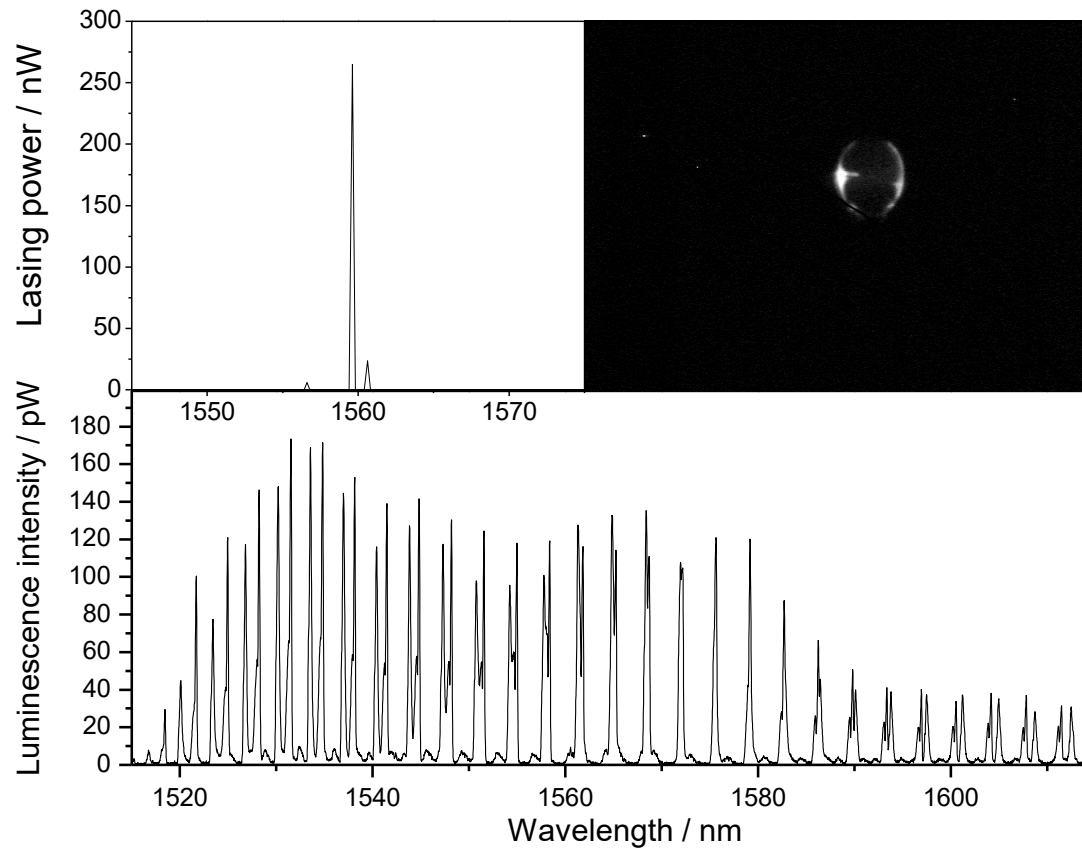
D. Ristić, A. Rasoloniaina, A. Chiappini, P. Féron, S. Pelli, G. Nunzi Conti, M. Ivanda, G. C. Righini, G. Cibiel, and M. Ferrari, About the role of phase matching between a coated microsphere and a tapered fiber: experimental study, Optics Express, 21, 20954-20963 (2013)

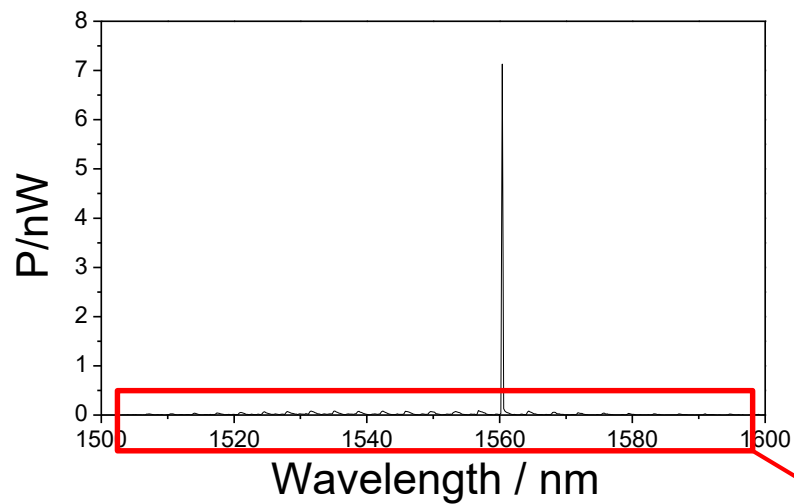
Coating of spherical microresonators: sol-gel



Microsized lasers

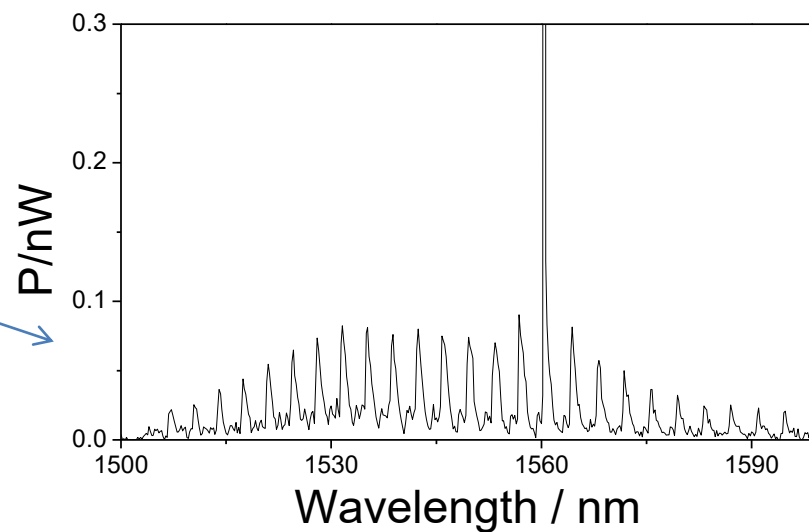
If coating on the microsphere is optically active the microsphere can lase if
 $\text{gain} > \text{loss}$

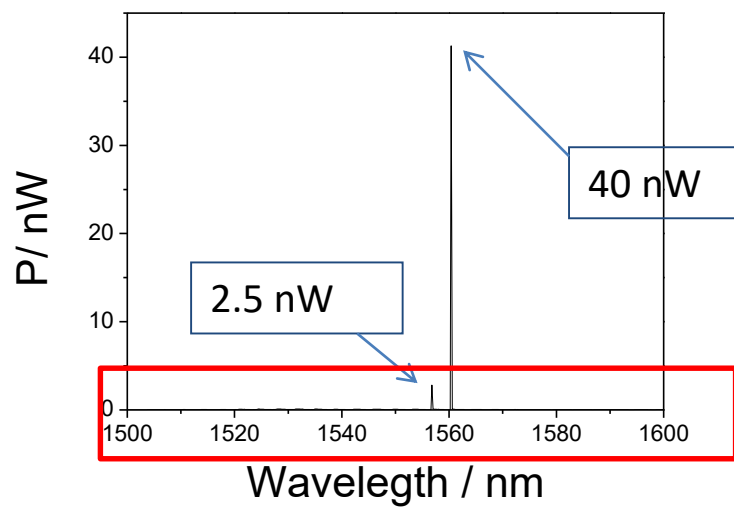




A typical single mode
lasing spectrum

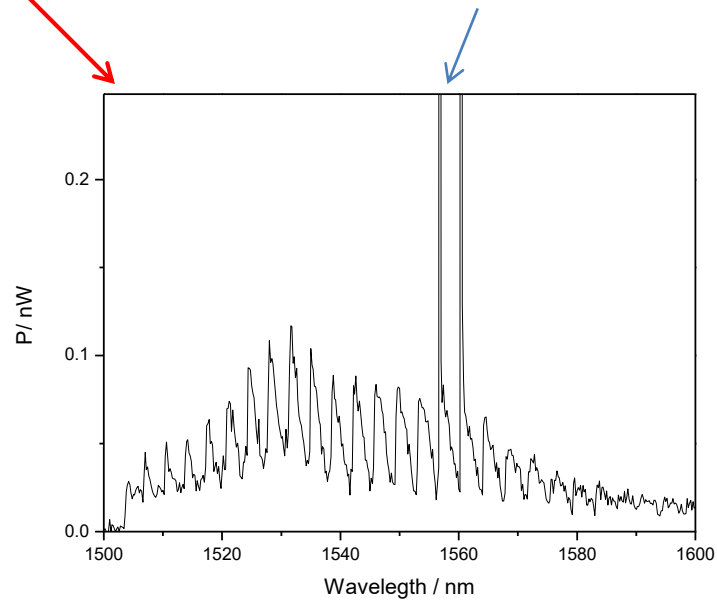
The lasing line corresponds to
a WGM mode peak

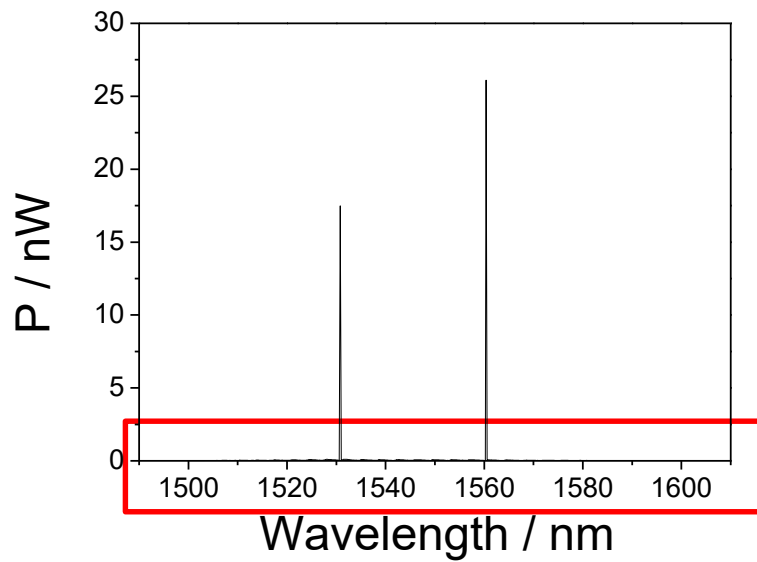




A typical multi mode
lasing spectrum

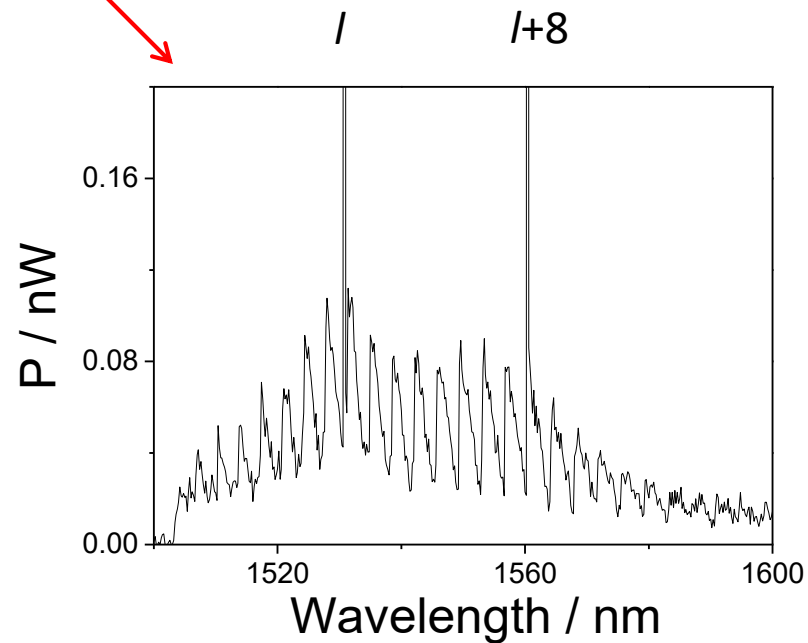
FSR=451 GHz

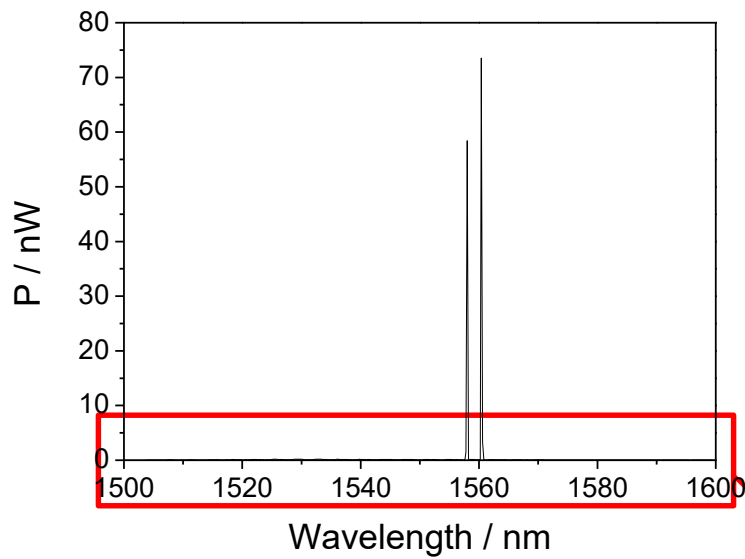




A typical multi mode
lasing spectrum

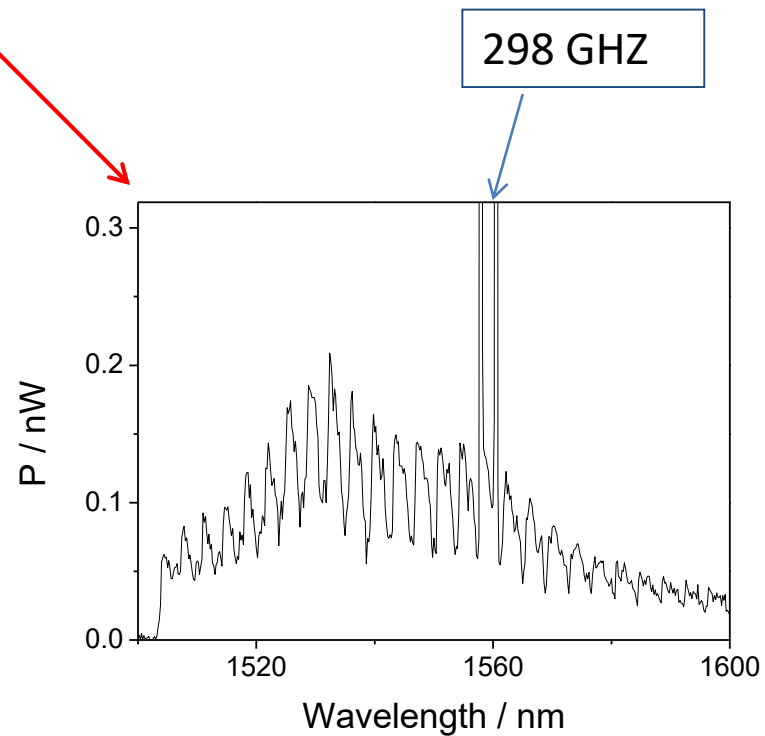
Possible lasing in any mode
between 1530 nm -1570 nm

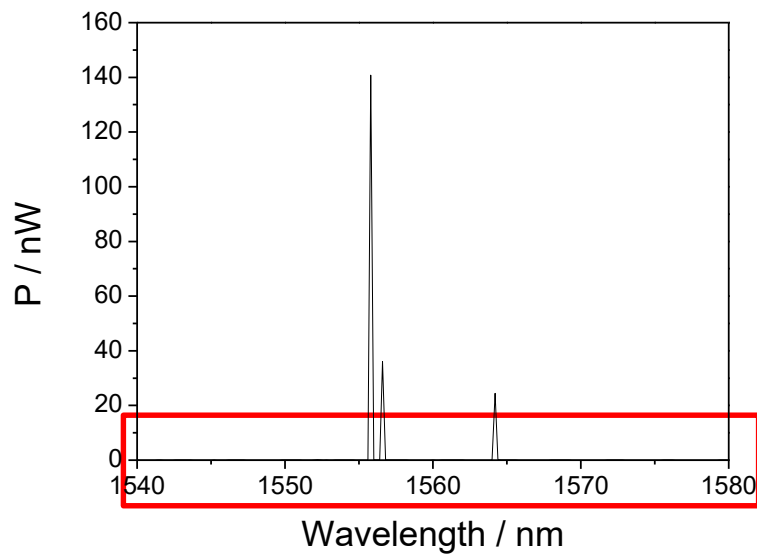




Two lasing modes visible

One TE and one TM mode are lasing, the λ values of the TE and TM modes are generally different



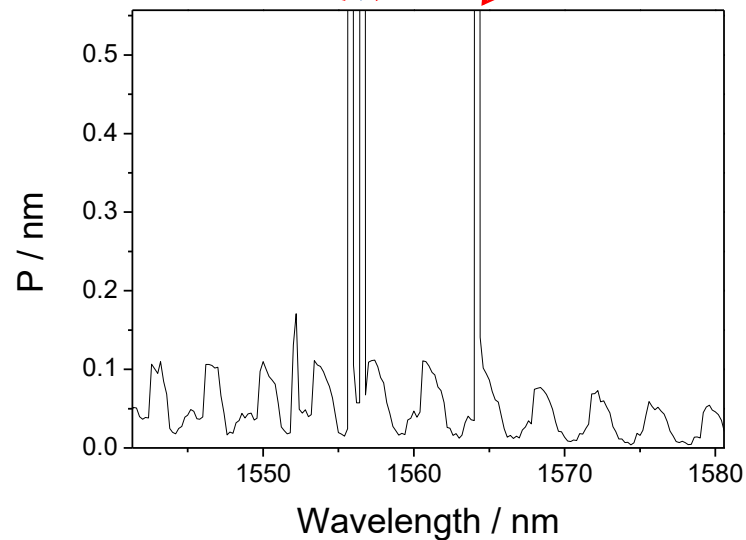


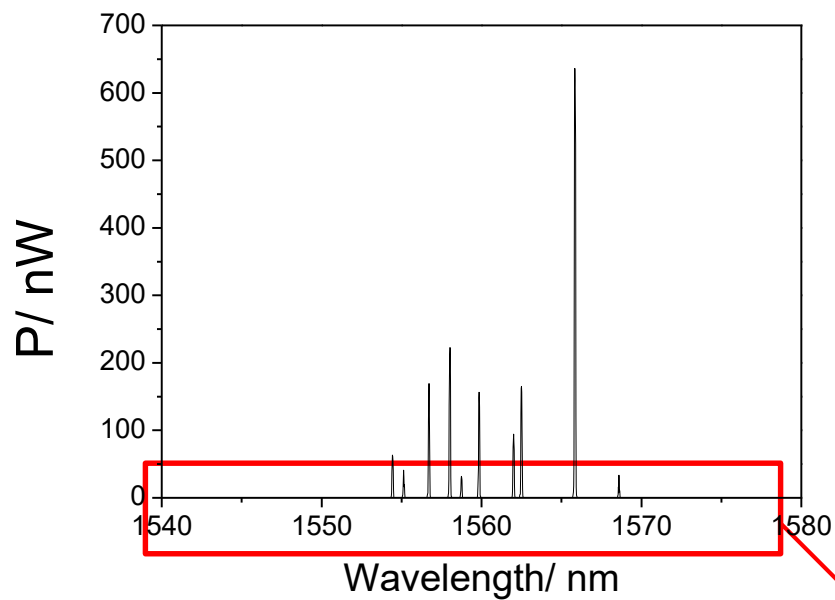
Three modes

100 GHz

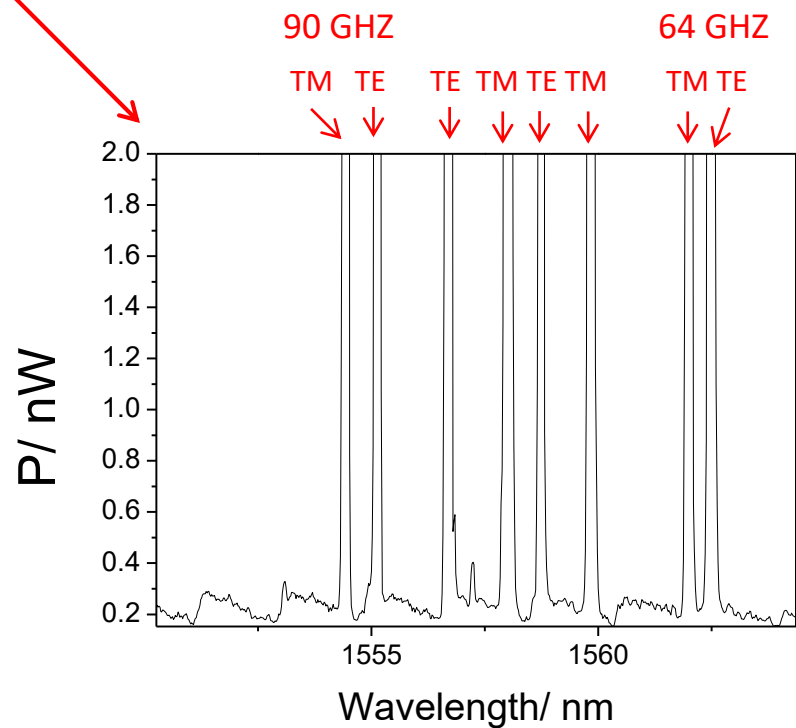
TE TM TE

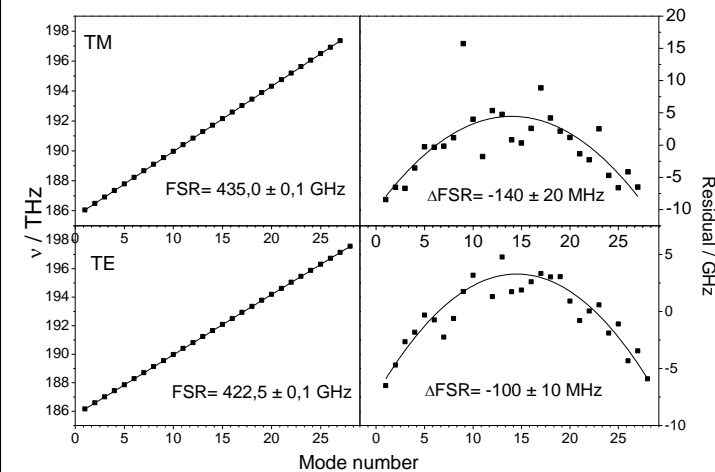
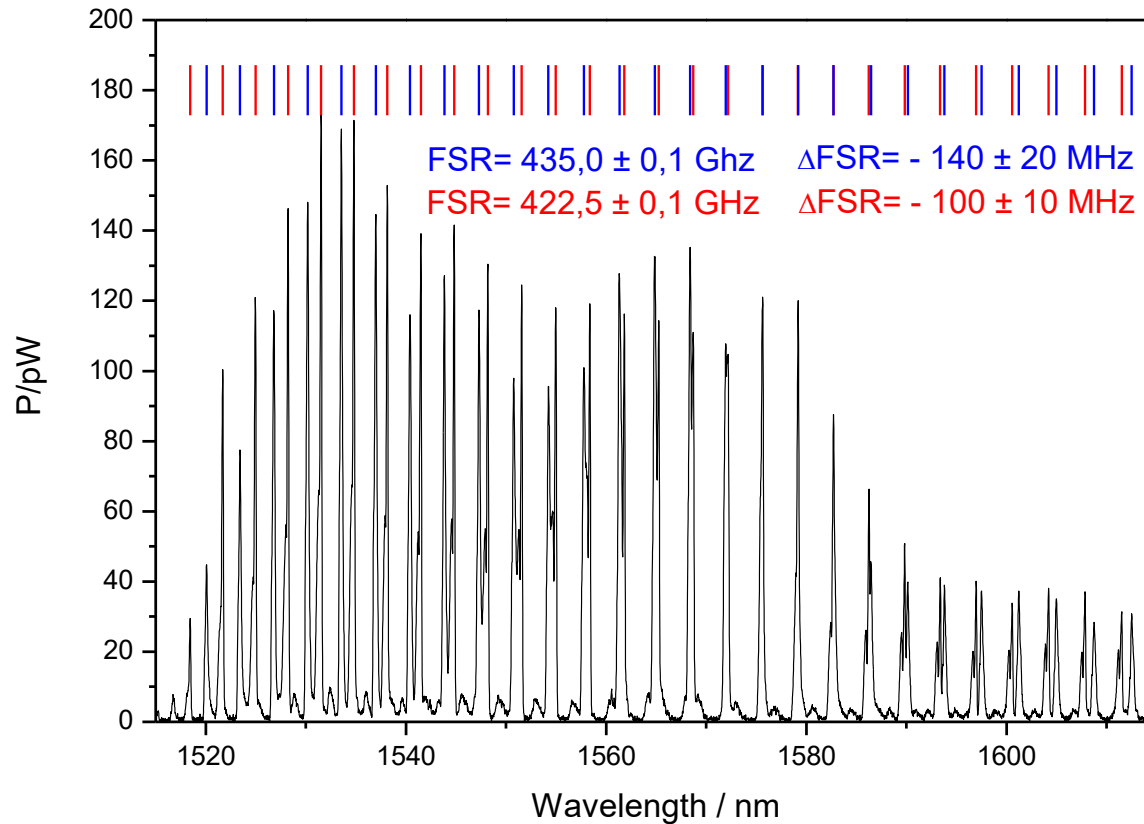
The TE – TM FSR can assume almost any value





The TE – TM FSR can assume almost any value

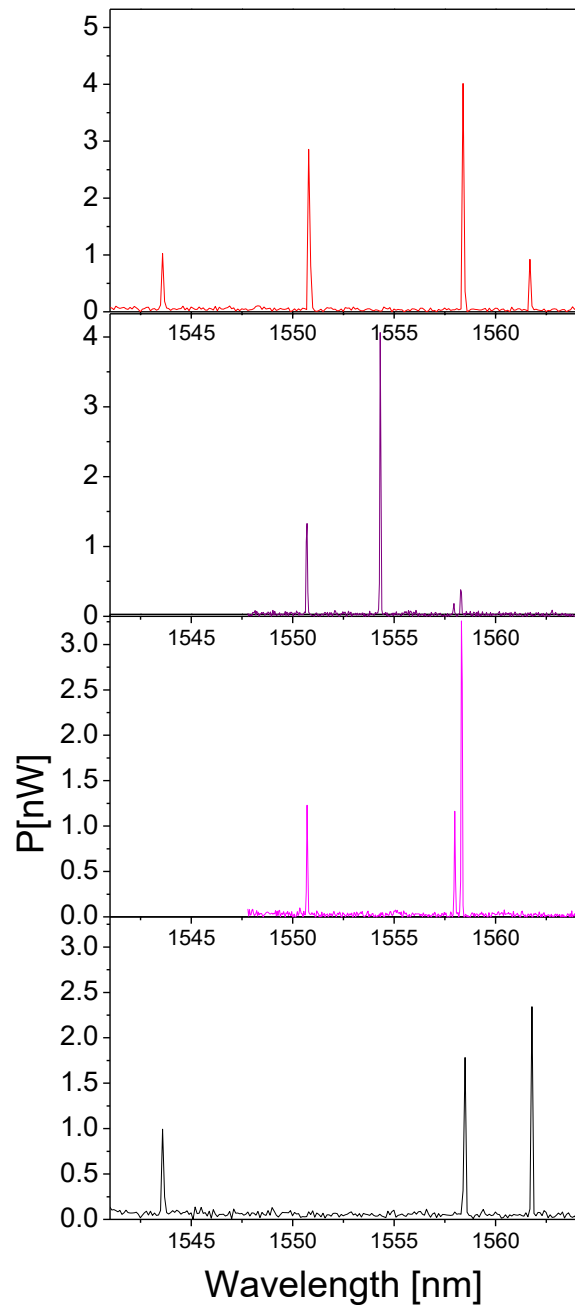




We managed to measure the overall modal dispersion using Er^{3+} as a probe

The measured modal dispersion is in agreement with theoretical predictions

D. Ristić, M. Mazzola, A. Chiappini, A. Rasoloniaina, P. Féron, R. Ramponi, G. C. Righini, G. Cibiel, M. Ivanda, and M. Ferrari, Tailoring of the free spectral range and geometrical cavity dispersion of a microsphere by a coating layer, *Optics Letters*, 39, 5173–5176 (2014).



Shifting from one lasing mode to another can be achieved very simply by moving the position of the sphere in respect to the taper

Acknowledgments

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