

The delicate details of blue-to-UV upconversion with Pr³⁺ – what is so challenging with this approach?

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After 50 years of continuous development, near infrared (NIR)-to-visible (VIS) upconversion with Er³⁺ and Yb³⁺ has become a mature research area [1] in the field of luminescent materials with various applications in bioimaging, or luminescent nanothermometry [2]. In contrast, upconversion of visible to ultraviolet (UV) light is by far not yet at that stage. Potential applications vary from photoredox catalysis to miniaturized antimicrobial light sources and so far, triplet-triplet annihilation (TTA) in organic emitters seem to be among the brightest options so far [3].

A possible candidate for blue-to-UV upconversion is the 4f² lanthanoid ion Pr³⁺. Despite its promising electric dipolar excited-state 4f¹5d¹ ← 4f² absorption, upconversion efficiencies are disappointingly low [3a]. In this lecture, I will address the fundamental obstacles in this approach referring back to the pioneering works of François Auzel and what could be potential outcomes [4,5]. Moreover, it will be covered how a follow-up energy transfer to the narrow-line emitting ion Gd³⁺ could be beneficially used and how important the choice of a suited host can be in the design of this energy transfer [5].

- [1] a) Menyuk, N., Dwight, K., Pierce, J. W. (1971), *Appl. Phys. Lett.* 21, 159–161; b) Krämer, K. W., Biner, D., Frei, G., Güdel, H. U., Hehlen, M. P., Lüthi, S. R. (2004), *Chem. Mater.* 16, 1244–1251.
[2] a) Mettenbrink, E. M., Yang, W., Wilhelm, S. (2022), *Adv. Photon. Res.* 3, 2200098; b) Brites, C. D. S., Marin, R., Suta, M., Carneiro Neto, A. N., Ximendes, E., Jaque, D., Carlos, L. D. (2023), *Adv. Mater.* 35, 2302749.
[3] a) Singh-Rachford, T. N., Castellano, F. (2010), *Coord. Chem. Rev.* 254, 2560–2573; b) Richards, B. S.; Hudry, D., Busko, D., Turshatov, A., Howard, I. A. (2021), *Chem. Rev.* 121, 9165–9195; c) Uji, M., Zähringer, T. J. B., Kerzig, C., Yanai, N. (2023), *Angew. Chem. Int. Ed.* 62, e202301506; d) Huang, L., Han, G. (2024), *Nat. Rev. Chem.* 8, 238–255; e) Feng, H.-J., Zhang, M.-Y., Jiang, L.-H., Huang, L., Pang, D.-W. (2025), *Acc. Chem. Res.* 58, 3543–3557.
[4] a) Auzel, F. (1966), *Comptes Rendus Acad. Sci. (Paris)* 262, 1016–1019; b) Ovsyankin, V. V., Feofilov, P. P. (1966), *Sov. Phys. JEPT Lett.* 4, 317c) Auzel, F. (1990), *J. Lumin.* 45, 341–345; d) Auzel, F. (2003), *Chem. Rev.* 104, 139–174; e) Auzel, F. (2020), *J. Lumin.* 223, 116900.
[5] a) Förster, T., Reifenberger, J., Moumin, T., Helmbold, J., Antić, Ž., Dramićanin, M. D., Suta, M. (2025), *Chem. Sci.* 16, 12309–12323; b) Förster T., Gedik, Y., Suta, M. (2026), in preparation; c) Förster, T., Stremel, M., Helmbold, J., Müller, R., Cerepanov, M., Suta, M. (2026), *Adv. Opt. Mater.*, in revision.

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