

# THE PHYSICS COLLOQUIUM

Thursday 21 May 2026, 4:00 p.m.  
Nijenborgh 4, Lecture Hall 5111.0080

## Ultra-Low Temperature NMR and DNP using cryogenic Helium MAS:

New insights on advanced nanomaterials  
from cellulose nanofibrils to perovskite nanocrystals

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Dynamic nuclear polarization (DNP)-enhanced solid-state magic angle spinning (MAS) NMR has greatly expanded the scope of sensitivity-limited experiments, enabling atomic-scale insights into complex biomolecular systems and functional materials.

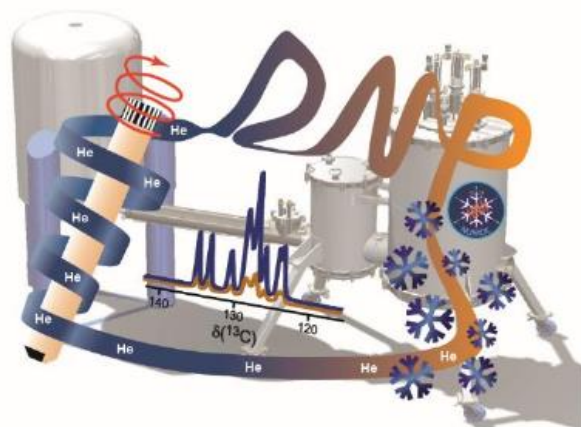
In the first part of this presentation, I will introduce the basic principles of high-field DNP and briefly review current hardware, polarizing agents and sample preparation enabling routine DNP experiments at 100 K. These developments have significantly improved sensitivity and opened new experimental possibilities.

I will illustrate these advances with representative examples from our research group, including probing the surface chemistry of functionalized silica nanoparticles via  $^{29}\text{Si}$ - $^{29}\text{Si}$  correlations,<sup>1</sup> and the structural characterization of milligram-scale organic and biological solids at natural isotopic abundance using multidimensional  $^{13}\text{C}$ - $^{13}\text{C}$  and  $^{15}\text{N}$ - $^{13}\text{C}$  correlation experiments.<sup>2,3</sup> I will further highlight how DNP provides unique insight into the surface chemistry of drug-functionalized<sup>4,5</sup> and surface-phosphorylated cellulose nanofibers,<sup>6</sup> and ZnO nanocrystals, revealing facet-specific ligand binding and ligand-ligand organization.<sup>7-9</sup>

In the second part, I will discuss ongoing efforts in our lab to further enhance DNP sensitivity by several orders of magnitude. These include the design of new polarizing agents guided by MAS-DNP simulations (e.g. AsymPol and PyrroTriPol),<sup>10-12</sup> as well as major instrumental advances toward sustainable ultra-low-temperature helium MAS.<sup>13-14</sup>

I will present the closed-loop helium system and DNP probe developed over the past decade, enabling simultaneous sample cooling and spinning down to  $\sim 20$  K, and yielding orders-of-magnitude of experimental time-savings compared to 100 K.<sup>15</sup> Finally, I will highlight new opportunities afforded by this approach through recent work on halide perovskite nanocrystals. While solution NMR has provided valuable insights into ligand binding dynamics, a detailed understanding of surface termination and stabilization remains limited due to sensitivity, even with DNP at 100 K.

I will show that cryogenic helium MAS overcomes these limitations by drastically reducing experimental times, enabling direct probing of ligand-surface and ligand-ligand interactions, revealing nanocrystal surface structures with unprecedented detail.<sup>15</sup>



References: [1] D. Lee et al., *J. Am. Chem. Soc.* (2014), 136, 39, 13781. [2] K. Märker et al., *J. Am. Chem. Soc.* (2015), 137, 43, 13796. [3] A. Smith et al., *J. Am. Chem. Soc.* (2018), 140, 44, 14576. [4] A. Kumar et al., *Chem. Sci.* (2020), 11, 3868. [5] A. Kumar et al., *Comm. Chem.* (2023), 6, 58. [6] T. Yagita et al., *J. Am. Chem. Soc.* (2026) 146, 4237. [7] D. Lee et al., *Angew. Chem. Int. Ed.* (2019) 58, 17163. [8] M. Terlecki et al., *Advanced Functional Materials* (2021) 10.1002/adfm.202105318. [9] S. Badoni et al., *J. Am. Chem. Soc.* (2024), 146, 40, 27655. [10] F. Mentink-Vigier et al., *J. Am. Chem. Soc.* (2018) 140, 35, 11013. [11] R. Harrabi, et al., *Angew. Chem. Intl. Ed.* (2022), 61, e202114103. [12] T. Halbritter et al., *Chem. Sci.* (2023) 14, 3852. [13] E. Bouleau et al., *Chem. Sci.* (2015) 6, 6806. [14] S. Paul et al., *JMR* (2023) 356, 107561. [15] N. Nath et al., under preparation

*Join us for coffee starting 3:30 p.m. Refreshments will be served after the lecture.*  
*For more information contact the hosts: Patrick van der Wel ([p.c.a.van.der.wel@rug.nl](mailto:p.c.a.van.der.wel@rug.nl))*  
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