Project 4.3 Ultracold but nonzero temperature one-dimensional Bose gases (theoretical)

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Background:

The physics of one-dimensional Bose gases has taken a prominent role in the field of ultracold atoms and various quantum technology applications in the last decade. Thus the 1d Bose gas is a topic of much modern research interest. In reduced spatial dimensions, where the particles cannot avoid collisions with each other, the interparticle interactions play an especially large role in the description of system, and in producing collective phenomena which are very different from typical superfluids.

The supervisors have recently developed a number of novel approaches to describe these gases. For strongly interacting integrable gases, a form factor hierarchy has been developed that allows one to systematically find the leading contributions to excitations in the Bethe ansatz. This opens a route to study correlations for larger numbers of strongly interacting particles and at nonzero temperature. For weakly interacting nonzero temperature gases, complex wave fields are usually used to describe the dynamics but suffer from ultraviolet divergences and a lack of quantum fluctuations in the description. Recently methods using a stochastic nonlinear Schrödinger equation were developed in our group that promise to overcome these barriers and allow, we hope, for a much more accurate study of solitons and other superfluid defects.

Aim:

We will research together novel nonzero temperature behaviour both in the strong and weak interaction regimes using the above two new approaches. Targets include: understanding the contributions to phase coherence and the Tan's contact in strongly interacting gases; characterising spontaneous thermal solitons and anomalous Kibble-Zurek mechanisms in the weakly interacting gas. An aim is for the PhD student to gain in-depth understanding of the physics and research methods of both strong and weak interacting low-dimensional quantum systems.

Requirements:

- research experience in theoretical physics,
- good programming skills or a strong willingness to learn them quickly,
- experience with ultracold gases, quantum optics, or quantum physics theory will be a strong advantage, as will experience with numerical calculations,
- Master's degree in physics (or an equivalent that qualifies one for PhD studies in physics in the country of issue),
- sufficient proficiency in the English language for efficient scientific interaction

Funding:

Scholarship: grant funding of 5000 PLN per month, from the NCN Polonez Bis project of Dr Taha Sant'Ana, before subtracting obligatory employer and employee social security contributions (~15%), for 18 months. Further grant funding may become available in future. After grant funding ends the default is the standard Polish PhD scholarship (about 2100 PLN/month net in the rest of year 2, then 3240 PLN/month net in years 3-4).

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