Heisenberg rings, qubits and quantum gates

Grzegorz Banaszak,[1] Dorota Blinkiewicz,[1] Piotr Krasoń,[2] and Jan Milewski[3]

[1] *Faculty of Mathematics and Computer Science, Adam Mickiewicz University*
[2] *Institute of Mathematics, Szczecin University*
[3] *Institute of Mathematics, Poznań University of Technology*

In this paper we continue our study of arithmetic operators and their potential applications for quantum computing (cf. G. Banaszak, D. Blinkiewicz, P. Krasoń, J. Milewski, Acta Physica Polonica A 133, no. 4, pp. 441–443 (2018)). We show how Galois symmetries allow us to compute the spectrum of the Heisenberg operators and Bethe parameters for the XXX model of the Heisenberg magnetic ring. We describe the construction of Galois qubits as well as the related quantum gates needed for quantum computing. This is done by means of arithmetic and algebraic properties of the Heisenberg operator which also significantly simplify the analysis of the model. We work out several examples shedding new light on these striking connections between physics, Galois theory, and algebraic number theory.