ETH Zürich, Dept. Informatik
WS 03/04

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Introduction to Quantum Computation
Übung 4

28.11.2002

4.1 Prove that $\{(e^{2\pi in\alpha}, e^{2\pi in\beta}) \mid n \in \mathbb{Z}\}$ is dense in the torus $S^1 \times S^1 = \{(z_1, z_2) \in \mathbb{C}^2 \mid |z_1| = |z_2| = 1\} \subset \mathbb{C}^2$ if and only if α, β and α/β are irrational.

4.2 Show that three CNOT gates (alternating the orientations, *i.e.*, alternating the roles of the control and "active" lines) implement a qubit swap operation. Write this out in matrices (it's probably not what you first expect it to be!).

4.3 Show how to use gates from the "standard universal family" to implement an arbitrary permutation matrix.