C*-ALGEBRAS, THE GELFAND-NAIMARK THEOREM, AND [OTHER THING]

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1. Introduction

1.1. **History of C*-Algebras.** The noncommutative nature of W. Heisenberg's work in [2] lead to Born and Jordan (find reference) developing the matrix mechanics required to concisely convey the new quantum mechanical model. From 1930-1943, J. von Neumann, together with F. J. Murray, developed the theory of *rings of operators* acting on a Hilbert space in [3], [4], [6], [5], in an attempt to establish a general framework for this matrix mechanics. These rings of operators are now considered part of the theory *von Neumann algebras*, a subsection of C*-algebra theory. In [1], Gelfand and Naimark established an abstract characterisation of C*-algebras, free from dependence on the operators acting on a Hilbert space. The Gelfand-Naimark, which we will be considering here at length, gives the link between these abstract C*-algebras and the rings of operators previously studied.

1.2. **C*-Algebras.** A brief overview of what a C*-algebra is.

- banach space
- banach algebra
- *-algebra
- C* algebra
- representations

Definition 1. *A* C*-algebra *is a Banach algebra* $(A, \|\cdot\|)$ *with involution* $* : A \to A$ *with the condition that*

$$\|x^*x\| = \|x\|^2 \text{ for all } x \in A.$$

This condition is known as the *C* axiom.* The study of C*-algebras started with the consideration of matrix mechanics by H

There are many statements of the theorem; this here comes from [ref].

Theorem (Gelfand-Naimark, Commutative)**.** *Every commutative, unital C*-algebra A is isometrically $*$-isomorphic to the algebra of continuous functions on the algebra of characters on A.*

The theorem first appeared in [gelfand-naimark] in a form relating 'normed rings' and a closed subrings of the set of bounded operators on a Hilbert space.

1.3. **Aims.** The aims for my project are, provisionally:

- Take the Gelfand-Naimark theorem, and understand its contents and proof.
- Consider the representation theory of C*-algebras, using the Gelfand-Naimark-Segal construction as a starting point.
- (as 'further reading') Give an overview of areas in which operator algebra theory can be taken (for example, Cuntz algebras and operator K-theory, von Neumann algebras and Factors, abstract harmonic analysis).

References

[1] Gelfand, I.; Neumark, M. *On the imbedding of normed rings into the ring of operators in Hilbert space.* Rec. Math. [Mat. Sbornik] N.S. 12(54), (1943), pp. 197-213.
[2] (find the ref for this paper)
[3] Murray, F. J.; von Neumann, J. *On rings of operators.* Ann. of Math. (2) 37 (1936), no. 1, pp. 116-229.
[4] Murray, F. J.; von Neumann, J. *On rings of operators. II* Trans. Amer. Math. Soc. 41 (1937), no. 2, pp. 208-248.
[5] Murray, F. J.; von Neumann, J. *On rings of operators. IV* Ann. of Math. (2) 44, (1943), pp. 716-808.
[6] von Neumann, J. *On rings of operators. III* Ann. of Math. (2) 41, (1940), pp. 94-161.