

Matrix Algebras with a Certain Compression Property

Zack Cramer

University of Waterloo

June 4th, 2018

Joint work with Laurent W. Marcoux and Heydar Radjavi

A subalgebra \mathcal{A} of $M_n(\mathbb{C})$ is

A subalgebra \mathcal{A} of $\mathbb{M}_n(\mathbb{C})$ is

projection compressible if $P\mathcal{A}P$ is an algebra for all $P = P^2 = P^*$ in $\mathbb{M}_n(\mathbb{C})$;

A subalgebra \mathcal{A} of $\mathbb{M}_n(\mathbb{C})$ is

projection compressible if $P\mathcal{A}P$ is an algebra for all $P = P^2 = P^*$ in $\mathbb{M}_n(\mathbb{C})$;

$$\mathcal{A} = \left[\begin{array}{c|c} \text{ran}(P) & \text{ker}(P) \\ \hline P\mathcal{A}P & \end{array} \right]$$

A subalgebra \mathcal{A} of $\mathbb{M}_n(\mathbb{C})$ is

projection compressible if $P\mathcal{A}P$ is an algebra for all $P = P^2 = P^*$ in $\mathbb{M}_n(\mathbb{C})$;

idempotent compressible if $E\mathcal{A}E$ is an algebra for all $E = E^2$ in $\mathbb{M}_n(\mathbb{C})$.

$$\mathcal{A} = \left[\begin{array}{c|c} \text{ran}(P) & \text{ker}(P) \\ \hline P\mathcal{A}P & \end{array} \right]$$

A subalgebra \mathcal{A} of $\mathbb{M}_n(\mathbb{C})$ is

projection compressible if $P\mathcal{A}P$ is an algebra for all $P = P^2 = P^*$ in $\mathbb{M}_n(\mathbb{C})$;

idempotent compressible if $E\mathcal{A}E$ is an algebra for all $E = E^2$ in $\mathbb{M}_n(\mathbb{C})$.

$$\mathcal{A} = \left[\begin{array}{c|c} \text{ran}(P) & \text{ker}(P) \\ \hline P\mathcal{A}P & \end{array} \right]$$

$$\mathcal{A} = \left[\begin{array}{c|c} \text{ran}(E) & \text{ker}(E) \\ \hline E\mathcal{A}E & \end{array} \right]$$

A subalgebra \mathcal{A} of $\mathbb{M}_n(\mathbb{C})$ is

projection compressible if $P\mathcal{A}P$ is an algebra for all $P = P^2 = P^*$ in $\mathbb{M}_n(\mathbb{C})$;

idempotent compressible if $E\mathcal{A}E$ is an algebra for all $E = E^2$ in $\mathbb{M}_n(\mathbb{C})$.

$$\mathcal{A} = \left[\begin{array}{c|c} \text{ran}(P) & \text{ker}(P) \\ \hline P\mathcal{A}P & \end{array} \right]$$

$$\mathcal{A} = \left[\begin{array}{c|c} \text{ran}(E) & \text{ker}(E) \\ \hline E\mathcal{A}E & \end{array} \right]$$

Assume \mathcal{A} is unital, field is \mathbb{C} .

Examples

Examples

$\mathbb{C}I$ and \mathbb{M}_n are idempotent compressible.

Examples

$\mathbb{C}I$ and \mathbb{M}_n are idempotent compressible.

$$\mathcal{D}_3 = \mathbb{C} \oplus \mathbb{C} \oplus \mathbb{C}$$

Examples

$\mathbb{C}I$ and \mathbb{M}_n are idempotent compressible.

$\mathcal{D}_3 = \mathbb{C} \oplus \mathbb{C} \oplus \mathbb{C}$ is not projection compressible.

Examples

$\mathbb{C}I$ and \mathbb{M}_n are idempotent compressible.

$\mathcal{D}_3 = \mathbb{C} \oplus \mathbb{C} \oplus \mathbb{C}$ is not projection compressible.

$$\text{If } P = \frac{1}{3} \begin{bmatrix} 2 & -1 & -1 \\ -1 & 2 & -1 \\ -1 & -1 & 2 \end{bmatrix},$$

Examples

$\mathbb{C}I$ and \mathbb{M}_n are idempotent compressible.

$\mathcal{D}_3 = \mathbb{C} \oplus \mathbb{C} \oplus \mathbb{C}$ is not projection compressible.

If $P = \frac{1}{3} \begin{bmatrix} 2 & -1 & -1 \\ -1 & 2 & -1 \\ -1 & -1 & 2 \end{bmatrix}$, then $A \in P\mathcal{D}_3P \Rightarrow a_{12} = a_{21}$.

Examples

$\mathbb{C}I$ and \mathbb{M}_n are idempotent compressible.

$\mathcal{D}_3 = \mathbb{C} \oplus \mathbb{C} \oplus \mathbb{C}$ is not projection compressible.

If $P = \frac{1}{3} \begin{bmatrix} 2 & -1 & -1 \\ -1 & 2 & -1 \\ -1 & -1 & 2 \end{bmatrix}$, then $A \in P\mathcal{D}_3P \Rightarrow a_{12} = a_{21}$.

However,

$$P \begin{bmatrix} 1 & & \\ & 0 & \\ & & 0 \end{bmatrix} P$$

Examples

$\mathbb{C}I$ and \mathbb{M}_n are idempotent compressible.

$\mathcal{D}_3 = \mathbb{C} \oplus \mathbb{C} \oplus \mathbb{C}$ is not projection compressible.

If $P = \frac{1}{3} \begin{bmatrix} 2 & -1 & -1 \\ -1 & 2 & -1 \\ -1 & -1 & 2 \end{bmatrix}$, then $A \in P\mathcal{D}_3P \Rightarrow a_{12} = a_{21}$.

However,

$$P \begin{bmatrix} 1 & & \\ & 0 & \\ & & 0 \end{bmatrix} P \cdot P \begin{bmatrix} 0 & & \\ & 1 & \\ & & 0 \end{bmatrix} P$$

Examples

$\mathbb{C}I$ and \mathbb{M}_n are idempotent compressible.

$\mathcal{D}_3 = \mathbb{C} \oplus \mathbb{C} \oplus \mathbb{C}$ is not projection compressible.

If $P = \frac{1}{3} \begin{bmatrix} 2 & -1 & -1 \\ -1 & 2 & -1 \\ -1 & -1 & 2 \end{bmatrix}$, then $A \in P\mathcal{D}_3P \Rightarrow a_{12} = a_{21}$.

However,

$$P \begin{bmatrix} 1 & & \\ & 0 & \\ & & 0 \end{bmatrix} P \cdot P \begin{bmatrix} 0 & & \\ & 1 & \\ & & 0 \end{bmatrix} P = \frac{1}{27} \begin{bmatrix} 2 & -4 & 2 \\ -1 & 2 & -1 \\ -1 & 2 & -1 \end{bmatrix}.$$

Examples

Examples

Note: $EAE \cdot EAE = E(\underbrace{AEA}_{\in \mathcal{A}})E$

Examples

Note: $EAE \cdot EAE = E \underbrace{(AEA)}_{\in \mathcal{A}} E$

(left ideal) \cap (right ideal)

Examples

Note: $EAE \cdot EAE = E \underbrace{(AEA)}_{\in \mathcal{A}} E$

$$(\text{left ideal}) \cap (\text{right ideal}) + \mathbb{C}I$$

Examples

Note: $EAE \cdot EAE = E \underbrace{(AEA)}_{\in \mathcal{A}} E$

(left ideal) \cap (right ideal) $+ \mathbb{C}I$



idempotent
compressible

Examples

Note: $EAE \cdot EAE = E \underbrace{(AEA)}_{\in \mathcal{A}} E$

(left ideal) \cap (right ideal) $+ \mathbb{C}I$



idempotent
compressible

E.g.,
$$\begin{bmatrix} * & 0 & 0 \\ 0 & * & * \\ 0 & * & * \end{bmatrix}$$

Examples

Note: $EAE \cdot EAE = E \underbrace{(AEA)}_{\in \mathcal{A}} E$

$$(\text{left ideal}) \cap (\text{right ideal}) + \mathbb{C}I \implies$$

idempotent
compressible

E.g.,
$$\begin{bmatrix} * & 0 & 0 \\ 0 & * & * \\ 0 & * & * \end{bmatrix} = \begin{bmatrix} 0 & * & * \\ 0 & * & * \\ 0 & * & * \end{bmatrix}$$

Examples

Note: $EAE \cdot EAE = E \underbrace{(AEA)}_{\in \mathcal{A}} E$

(left ideal) \cap (right ideal) $+ \mathbb{C}I \implies$ idempotent
compressible

E.g.,
$$\begin{bmatrix} * & 0 & 0 \\ 0 & * & * \\ 0 & * & * \end{bmatrix} = \begin{bmatrix} 0 & * & * \\ 0 & * & * \\ 0 & * & * \end{bmatrix} \cap \begin{bmatrix} 0 & 0 & 0 \\ * & * & * \\ * & * & * \end{bmatrix}$$

Examples

Note: $EAE \cdot EAE = E \underbrace{(AEA)}_{\in \mathcal{A}} E$

(left ideal) \cap (right ideal) $+ \mathbb{C}I \implies$ idempotent compressible

E.g.,
$$\begin{bmatrix} * & 0 & 0 \\ 0 & * & * \\ 0 & * & * \end{bmatrix} = \begin{bmatrix} 0 & * & * \\ 0 & * & * \\ 0 & * & * \end{bmatrix} \cap \begin{bmatrix} 0 & 0 & 0 \\ * & * & * \\ * & * & * \end{bmatrix} + \mathbb{C}I$$

Examples

Note: $EAE \cdot EAE = E \underbrace{(AEA)}_{\in \mathcal{A}} E$

(left ideal) \cap (right ideal) $+ \mathbb{C}I \implies$ idempotent compressible

E.g.,
$$\begin{bmatrix} * & 0 & 0 \\ 0 & * & * \\ 0 & * & * \end{bmatrix} = \begin{bmatrix} 0 & * & * \\ 0 & * & * \\ 0 & * & * \end{bmatrix} \cap \begin{bmatrix} 0 & 0 & 0 \\ * & * & * \\ * & * & * \end{bmatrix} + \mathbb{C}I$$

Also idempotent compressible: $\mathcal{T}_3 := \begin{bmatrix} * & * & * \\ 0 & * & * \\ 0 & 0 & * \end{bmatrix}$

Examples

Examples

NOT projection compressible:

Examples

NOT projection compressible:

$$\begin{bmatrix} M_2 & 0 \\ 0 & M_2 \end{bmatrix}$$

Examples

NOT projection compressible:

$$\begin{bmatrix} M_2 & 0 \\ 0 & M_2 \end{bmatrix}$$

$$\begin{bmatrix} M_2 & M_2 \\ 0 & M_2 \end{bmatrix}$$

Examples

NOT projection compressible:

$$\begin{bmatrix} M_2 & 0 \\ 0 & M_2 \end{bmatrix}$$

$$\begin{bmatrix} M_2 & M_2 \\ 0 & M_2 \end{bmatrix}$$

$$\begin{bmatrix} \alpha & & & \\ & \beta & & \\ & & \alpha & \\ & & & \beta \end{bmatrix}$$

Examples

NOT projection compressible:

$$\begin{bmatrix} M_2 & 0 \\ 0 & M_2 \end{bmatrix}$$

$$\begin{bmatrix} M_2 & M_2 \\ 0 & M_2 \end{bmatrix}$$

$$\begin{bmatrix} \alpha & & & \\ & \beta & & \\ & & \alpha & \\ & & & \beta \end{bmatrix}$$

$$\begin{bmatrix} * & * & * & * \\ & * & * & * \\ & & * & * \\ & & & * \end{bmatrix}$$

Examples

NOT projection compressible:

$$\begin{bmatrix} M_2 & 0 \\ 0 & M_2 \end{bmatrix}$$

$$\begin{bmatrix} M_2 & M_2 \\ 0 & M_2 \end{bmatrix}$$

$$\begin{bmatrix} \alpha & & & \\ & \beta & & \\ & & \alpha & \\ & & & \beta \end{bmatrix}$$

$$\begin{bmatrix} * & * & * & * \\ & * & * & * \\ & & * & * \\ & & & * \end{bmatrix}$$

Idempotent compressible:

Examples

NOT projection compressible:

$$\begin{bmatrix} M_2 & 0 \\ 0 & M_2 \end{bmatrix}$$

$$\begin{bmatrix} M_2 & M_2 \\ 0 & M_2 \end{bmatrix}$$

$$\begin{bmatrix} \alpha & & & \\ & \beta & & \\ & & \alpha & \\ & & & \beta \end{bmatrix}$$

$$\begin{bmatrix} * & * & * & * \\ & * & * & * \\ & & * & * \\ & & & * \end{bmatrix}$$

Idempotent compressible:

$$\begin{bmatrix} \alpha & * & * & * \\ & M_2 & & * \\ & & & * \\ & & & \beta \end{bmatrix}$$

Examples

NOT projection compressible:

$$\begin{bmatrix} M_2 & 0 \\ 0 & M_2 \end{bmatrix}$$

$$\begin{bmatrix} M_2 & M_2 \\ 0 & M_2 \end{bmatrix}$$

$$\begin{bmatrix} \alpha & & & \\ & \beta & & \\ & & \alpha & \\ & & & \beta \end{bmatrix}$$

$$\begin{bmatrix} * & * & * & * \\ & * & * & * \\ & & * & * \\ & & & * \end{bmatrix}$$

Idempotent compressible:

$$\begin{bmatrix} \alpha & * & * & * \\ & M_2 & & * \\ & & & * \\ & & & \beta \end{bmatrix}$$

$$\begin{bmatrix} \alpha & & * & * \\ & \beta & * & * \\ & & \gamma & \\ & & & \gamma \end{bmatrix}$$

Examples

NOT projection compressible:

$$\begin{bmatrix} M_2 & 0 \\ 0 & M_2 \end{bmatrix}$$

$$\begin{bmatrix} M_2 & M_2 \\ 0 & M_2 \end{bmatrix}$$

$$\begin{bmatrix} \alpha & & & \\ & \beta & & \\ & & \alpha & \\ & & & \beta \end{bmatrix}$$

$$\begin{bmatrix} * & * & * & * \\ & * & * & * \\ & & * & * \\ & & & * \end{bmatrix}$$

Idempotent compressible:

$$\begin{bmatrix} \alpha & * & * & * \\ & M_2 & & * \\ & & & * \\ & & & \beta \end{bmatrix}$$

$$\begin{bmatrix} \alpha & * & * \\ & \beta & * & * \\ & & \gamma & \\ & & & \gamma \end{bmatrix}$$

$$\begin{bmatrix} \alpha & * & * & * \\ & \alpha & * & * \\ & & \gamma & \\ & & & \gamma \end{bmatrix}$$

Structure of \mathcal{P} -Compressible Algebras

Structure of \mathcal{P} -Compressible Algebras

Suppose $\mathcal{A} = \begin{bmatrix} \mathcal{A}_{11} & \mathcal{A}_{12} \\ 0 & \mathcal{A}_{22} \end{bmatrix} \subseteq \mathbb{M}_{n+m}$, $n, m \geq 2$.

Structure of \mathcal{P} -Compressible Algebras

Suppose $\mathcal{A} = \begin{bmatrix} \mathcal{A}_{11} & \mathcal{A}_{12} \\ 0 & \mathcal{A}_{22} \end{bmatrix} \subseteq \mathbb{M}_{n+m}$, $n, m \geq 2$.

If \mathcal{A} is projection compressible, then $\mathcal{A}_{11} = \mathbb{C}I$ or $\mathcal{A}_{22} = \mathbb{C}I$.

Structure of \mathcal{P} -Compressible Algebras

Suppose $\mathcal{A} = \begin{bmatrix} \mathcal{A}_{11} & \mathcal{A}_{12} \\ 0 & \mathcal{A}_{22} \end{bmatrix} \subseteq \mathbb{M}_{n+m}$, $n, m \geq 2$.

If \mathcal{A} is projection compressible, then $\mathcal{A}_{11} = \mathbb{C}I$ or $\mathcal{A}_{22} = \mathbb{C}I$.

Burnside: If $\mathcal{A} \neq \mathbb{M}_n$, then

Structure of \mathcal{P} -Compressible Algebras

Suppose $\mathcal{A} = \begin{bmatrix} \mathcal{A}_{11} & \mathcal{A}_{12} \\ 0 & \mathcal{A}_{22} \end{bmatrix} \subseteq \mathbb{M}_{n+m}$, $n, m \geq 2$.

If \mathcal{A} is projection compressible, then $\mathcal{A}_{11} = \mathbb{C}I$ or $\mathcal{A}_{22} = \mathbb{C}I$.

Burnside: If $\mathcal{A} \neq \mathbb{M}_n$, then

$$\mathcal{A} \simeq \begin{bmatrix} \boxed{\phantom{\mathbb{M}_n}} & \boxed{\phantom{\mathbb{M}_m}} \\ 0 & \boxed{\phantom{\mathbb{M}_m}} \end{bmatrix}$$

Structure of \mathcal{P} -Compressible Algebras

Suppose $\mathcal{A} = \begin{bmatrix} \mathcal{A}_{11} & \mathcal{A}_{12} \\ 0 & \mathcal{A}_{22} \end{bmatrix} \subseteq \mathbb{M}_{n+m}$, $n, m \geq 2$.

If \mathcal{A} is projection compressible, then $\mathcal{A}_{11} = \mathbb{C}I$ or $\mathcal{A}_{22} = \mathbb{C}I$.

Burnside: If $\mathcal{A} \neq \mathbb{M}_n$, then

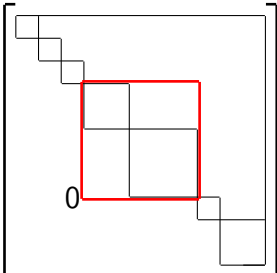
$$\mathcal{A} \simeq \begin{bmatrix} \square & & & & \\ & \square & & & \\ & & \square & & \\ & & & \square & \\ & 0 & & & \square \end{bmatrix}$$

Structure of \mathcal{P} -Compressible Algebras

Suppose $\mathcal{A} = \begin{bmatrix} \mathcal{A}_{11} & \mathcal{A}_{12} \\ 0 & \mathcal{A}_{22} \end{bmatrix} \subseteq \mathbb{M}_{n+m}$, $n, m \geq 2$.

If \mathcal{A} is projection compressible, then $\mathcal{A}_{11} = \mathbb{C}I$ or $\mathcal{A}_{22} = \mathbb{C}I$.

Burnside: If $\mathcal{A} \neq \mathbb{M}_n$, then

$$\mathcal{A} \simeq \left[\begin{array}{c} \begin{array}{c} \square \\ \square \\ \square \end{array} \\ \begin{array}{c} \square \\ \square \\ \square \\ \square \end{array} \\ \begin{array}{c} \square \\ \square \\ \square \\ \square \\ \square \end{array} \\ \begin{array}{c} \square \\ \square \\ \square \\ \square \\ \square \\ \square \end{array} \end{array} \right]$$
The diagram shows a large square matrix enclosed in large square brackets. The matrix is partitioned into a grid of smaller squares. A red box highlights a 2x2 sub-block in the lower-middle part of the matrix. The bottom-left corner of this red box is labeled with the number '0'. The overall structure represents a block upper triangular matrix with a specific sub-block highlighted.

Structure of \mathcal{P} -Compressible Algebras

Suppose $\mathcal{A} = \begin{bmatrix} \mathcal{A}_{11} & \mathcal{A}_{12} \\ 0 & \mathcal{A}_{22} \end{bmatrix} \subseteq \mathbb{M}_{n+m}$, $n, m \geq 2$.

If \mathcal{A} is projection compressible, then $\mathcal{A}_{11} = \mathbb{C}I$ or $\mathcal{A}_{22} = \mathbb{C}I$.

Burnside: If $\mathcal{A} \neq \mathbb{M}_n$, then

$$\mathcal{A} \simeq \begin{bmatrix} \begin{array}{c} \square \\ \square \\ \square \\ \square \\ \square \\ \square \end{array} & & \\ & 0 & \begin{array}{c} \square \\ \square \\ \square \\ \square \\ \square \end{array} \end{bmatrix}$$

Structure of \mathcal{P} -Compressible Algebras

Suppose $\mathcal{A} = \begin{bmatrix} \mathcal{A}_{11} & \mathcal{A}_{12} \\ 0 & \mathcal{A}_{22} \end{bmatrix} \subseteq \mathbb{M}_{n+m}$, $n, m \geq 2$.

If \mathcal{A} is projection compressible, then $\mathcal{A}_{11} = \mathbb{C}I$ or $\mathcal{A}_{22} = \mathbb{C}I$.

Burnside: If $\mathcal{A} \neq \mathbb{M}_n$, then

$$\mathcal{A} \simeq \begin{bmatrix} \mathbb{C}I & & & \\ & & & \\ & & \mathbb{M}_k & \\ 0 & & & \\ & & & \mathbb{C}I \end{bmatrix}$$

Structure of \mathcal{P} -Compressible Algebras

Suppose $\mathcal{A} = \begin{bmatrix} \mathcal{A}_{11} & \mathcal{A}_{12} \\ 0 & \mathcal{A}_{22} \end{bmatrix} \subseteq \mathbb{M}_{n+m}$, $n, m \geq 2$.

If \mathcal{A} is projection compressible, then $\mathcal{A}_{11} = \mathbb{C}I$ or $\mathcal{A}_{22} = \mathbb{C}I$.

Burnside: If $\mathcal{A} \neq \mathbb{M}_n$, then

$$\mathcal{A} \simeq \begin{bmatrix} \mathbb{C}I & ? & ? \\ 0 & \mathbb{M}_k & ? \\ & & \mathbb{C}I \end{bmatrix}$$

“Unhinging” an Algebra

“Unhinging” an Algebra

There is a block upper triangular S such that $S^{-1}AS$ is “unhinged”:

“Unhinging” an Algebra

There is a block upper triangular S such that $S^{-1}AS$ is “unhinged”:

$$\begin{bmatrix} \boxed{\mathbb{C}I} & \boxed{?} & \boxed{?} \\ & \boxed{\mathbb{M}_k} & \boxed{?} \\ & & \boxed{\mathbb{C}I} \end{bmatrix}$$

A

“Unhinging” an Algebra

There is a block upper triangular S such that $S^{-1}\mathcal{A}S$ is “unhinged”:

$$\begin{bmatrix} \boxed{CI} & \boxed{?} & \boxed{?} \\ & \boxed{M_k} & \boxed{?} \\ & & \boxed{CI} \end{bmatrix} \sim \mathcal{A} \sim$$

“Unhinging” an Algebra

There is a block upper triangular S such that $S^{-1}\mathcal{A}S$ is “unhinged”:

$$\begin{bmatrix} \boxed{CI} & \boxed{?} & \boxed{?} \\ & \boxed{M_k} & \boxed{?} \\ & & \boxed{CI} \end{bmatrix} \sim \begin{bmatrix} \boxed{CI} & & \\ & \boxed{M_k} & \\ & & \boxed{CI} \end{bmatrix}$$

$\mathcal{A} \quad \sim \quad \text{BlockDiag}(\mathcal{A})$

“Unhinging” an Algebra

There is a block upper triangular S such that $S^{-1}\mathcal{A}S$ is “unhinged”:

$$\begin{array}{c} \left[\begin{array}{|c|c|c|} \hline \mathbb{C}I & ? & ? \\ \hline & \mathbb{M}_k & ? \\ \hline & & \mathbb{C}I \\ \hline \end{array} \right] \\ \mathcal{A} \end{array} \sim \begin{array}{c} \left[\begin{array}{|c|} \hline \mathbb{C}I \\ \hline \end{array} \right] \\ \sim \\ \text{BlockDiag}(\mathcal{A}) \end{array} \dot{+} \begin{array}{c} \left[\begin{array}{|c|c|} \hline ? & ? \\ \hline & ? \\ \hline \end{array} \right] \\ \text{Rad}(\mathcal{A}) \end{array}$$

“Unhinging” an Algebra

There is a block upper triangular S such that $S^{-1}\mathcal{A}S$ is “unhinged”:

$$\begin{array}{c} \left[\begin{array}{|c|c|c|} \hline \mathbb{C}I & ? & ? \\ \hline & \mathbb{M}_k & ? \\ \hline & & \mathbb{C}I \\ \hline \end{array} \right] \\ \mathcal{A} \end{array} \sim \begin{array}{c} \left[\begin{array}{|c|} \hline \mathbb{C}I \\ \hline \end{array} \right] \\ \sim \\ \text{BlockDiag}(\mathcal{A}) \end{array} \dot{+} \begin{array}{c} \left[\begin{array}{|c|c|} \hline \mathcal{A}_{12} & \mathcal{A}_{13} \\ \hline & \mathcal{A}_{23} \\ \hline \end{array} \right] \\ \text{Rad}(\mathcal{A}) \end{array}$$

“Unhinging” an Algebra

There is a block upper triangular S such that $S^{-1}\mathcal{A}S$ is “unhinged”:

$$\begin{array}{c} \left[\begin{array}{|c|c|c|} \hline \mathbb{C}I & ? & ? \\ \hline & \mathbb{M}_k & ? \\ \hline & & \mathbb{C}I \\ \hline \end{array} \right] \\ \mathcal{A} \end{array} \sim \begin{array}{c} \left[\begin{array}{|c|} \hline \mathbb{C}I \\ \hline \end{array} \right] \\ \sim \\ \text{BlockDiag}(\mathcal{A}) \end{array} \dot{+} \begin{array}{c} \left[\begin{array}{|c|c|} \hline \mathcal{A}_{12} & \mathcal{A}_{13} \\ \hline & \mathcal{A}_{23} \\ \hline \end{array} \right] \\ \text{Rad}(\mathcal{A}) \end{array}$$

Note: We can't do $S^{-1}\mathcal{A}S$ with projection compressibility.

“Unhinging” an Algebra

There is a block upper triangular S such that $S^{-1}\mathcal{A}S$ is “unhinged”:

$$\begin{array}{c} \left[\begin{array}{|c|c|c|} \hline \mathbb{C}I & ? & ? \\ \hline & \mathbb{M}_k & ? \\ \hline & & \mathbb{C}I \\ \hline \end{array} \right] \\ \mathcal{A} \end{array} \sim \begin{array}{c} \left[\begin{array}{|c|} \hline \mathbb{C}I \\ \hline \end{array} \right] \\ \left[\begin{array}{|c|} \hline \mathbb{M}_k \\ \hline \end{array} \right] \\ \left[\begin{array}{|c|} \hline \mathbb{C}I \\ \hline \end{array} \right] \end{array} \dagger \begin{array}{c} \left[\begin{array}{|c|c|} \hline \mathcal{A}_{12} & \mathcal{A}_{13} \\ \hline & \mathcal{A}_{23} \\ \hline \end{array} \right] \\ \text{Rad}(\mathcal{A}) \end{array}$$

$\sim \text{BlockDiag}(\mathcal{A}) \dagger \text{Rad}(\mathcal{A})$

Note: We can't do $S^{-1}\mathcal{A}S$ with projection compressibility...
...but for idempotents, it's no problem!

Idempotent Compressibility

Idempotent Compressibility

Theorem: Let \mathcal{A} be a unital subalgebra of \mathbb{M}_n ($n \geq 4$).

TFAE:

Idempotent Compressibility

Theorem: Let \mathcal{A} be a unital subalgebra of \mathbb{M}_n ($n \geq 4$).

TFAE:

- (i) \mathcal{A} is idempotent compressible;

Idempotent Compressibility

Theorem: Let \mathcal{A} be a unital subalgebra of \mathbb{M}_n ($n \geq 4$).

TFAE:

- (i) \mathcal{A} is idempotent compressible;
- (ii) $\mathcal{A} = \mathcal{L} \cap \mathcal{R} + \mathbb{C}I$

Idempotent Compressibility

Theorem: Let \mathcal{A} be a unital subalgebra of \mathbb{M}_n ($n \geq 4$).

TFAE:

- (i) \mathcal{A} is idempotent compressible;
- (ii) $\mathcal{A} = \mathcal{L} \cap \mathcal{R} + \mathbb{C}I$, or \mathcal{A} is similar to one of the following:

Idempotent Compressibility

Theorem: Let \mathcal{A} be a unital subalgebra of \mathbb{M}_n ($n \geq 4$).

TFAE:

- (i) \mathcal{A} is idempotent compressible;
- (ii) $\mathcal{A} = \mathcal{L} \cap \mathcal{R} + \mathbb{C}I$, or \mathcal{A} is similar to one of the following:

$$\left[\begin{array}{|c|c|c|} \hline \mathbb{C}I & * & * \\ \hline & \mathbb{M}_k & * \\ \hline & & \mathbb{C}I \\ \hline \end{array} \right]$$

Idempotent Compressibility

Theorem: Let \mathcal{A} be a unital subalgebra of \mathbb{M}_n ($n \geq 4$).

TFAE:

- (i) \mathcal{A} is idempotent compressible;
- (ii) $\mathcal{A} = \mathcal{L} \cap \mathcal{R} + \mathbb{C}I$, or \mathcal{A} is similar to one of the following:

$$\left[\begin{array}{|c|c|c|} \hline \mathbb{C}I & * & * \\ \hline & \mathbb{M}_k & * \\ \hline & & \mathbb{C}I \\ \hline \end{array} \right], \quad , \quad \left[\begin{array}{|c|c|} \hline \alpha & * \\ \hline \beta & * \\ \hline & \begin{array}{c} \gamma \gamma \\ \diagdown \\ \gamma \end{array} \\ \hline \end{array} \right]$$

Idempotent Compressibility

Theorem: Let \mathcal{A} be a unital subalgebra of \mathbb{M}_n ($n \geq 4$).

TFAE:

- (i) \mathcal{A} is idempotent compressible;
- (ii) $\mathcal{A} = \mathcal{L} \cap \mathcal{R} + \mathbb{C}I$, or \mathcal{A} is similar to one of the following:

$$\left[\begin{array}{|c|c|c|} \hline \mathbb{C}I & * & * \\ \hline & \mathbb{M}_k & * \\ \hline & & \mathbb{C}I \\ \hline \end{array} \right], \quad \left[\begin{array}{|c|c|} \hline \alpha & * \\ \hline \beta & * \\ \hline \gamma & \gamma \\ \hline & \gamma \\ \hline \end{array} \right], \quad \left[\begin{array}{|c|c|c|} \hline \alpha & * & * \\ \hline & \alpha & * \\ \hline \gamma & \gamma & \\ \hline & & \gamma \\ \hline \end{array} \right]$$

Idempotent Compressibility

Theorem: Let \mathcal{A} be a unital subalgebra of \mathbb{M}_n ($n \geq 4$).

TFAE:

- (i) \mathcal{A} is idempotent compressible;
- (ii) $\mathcal{A} = \mathcal{L} \cap \mathcal{R} + \mathbb{C}I$, or \mathcal{A} is similar to one of the following:

$$\left[\begin{array}{|c|c|c|} \hline \mathbb{C}I & * & * \\ \hline & \mathbb{M}_k & * \\ \hline & & \mathbb{C}I \\ \hline \end{array} \right], \quad \left[\begin{array}{|c|c|c|} \hline \alpha & * & * \\ \hline & \beta & * \\ \hline & & \gamma \text{ } \gamma \\ \hline \end{array} \right], \quad \left[\begin{array}{|c|c|c|} \hline \alpha & * & * \\ \hline & \alpha & * \\ \hline & & \gamma \text{ } \gamma \\ \hline \end{array} \right]$$

$$\left[\begin{array}{cccc} \alpha & * & * & * \\ & & & * \\ & \mathbb{M}_2 & & * \\ & & & * \\ & & & \beta \end{array} \right]$$

$$\left[\begin{array}{ccc} \alpha & * & * \\ & \beta & * \\ & & \gamma \\ & & \gamma \end{array} \right]$$

$$\left[\begin{array}{cccc} \alpha & * & * & * \\ & \alpha & * & * \\ & & \gamma & \\ & & & \gamma \end{array} \right]$$

Projection Compressibility?

Projection Compressibility?

$$\begin{bmatrix} \mathbb{C}I & ? & ? \\ & M_k & ? \\ & & \mathbb{C}I \end{bmatrix} \sim \begin{bmatrix} \mathbb{C}I & & \\ & M_k & \\ & & \mathbb{C}I \end{bmatrix} + \begin{bmatrix} \mathcal{A}_{12} & \mathcal{A}_{13} \\ & \mathcal{A}_{23} \end{bmatrix} =: \mathcal{A}'$$

Projection Compressibility?

$$\begin{bmatrix} \mathbb{C}I & ? & ? \\ & M_k & ? \\ & & \mathbb{C}I \end{bmatrix} \sim \begin{bmatrix} \mathbb{C}I & & \\ & M_k & \\ & & \mathbb{C}I \end{bmatrix} + \begin{bmatrix} \mathcal{A}_{12} & \mathcal{A}_{13} \\ & \mathcal{A}_{23} \end{bmatrix} =: \mathcal{A}'$$

Idea: If \mathcal{A}' is not idempotent compressible, then no similarity $S^{-1}\mathcal{A}'S$ is projection compressible.

Projection Compressibility?

$$\begin{bmatrix} \mathbb{C}I & ? & ? \\ & \mathbb{M}_k & ? \\ & & \mathbb{C}I \end{bmatrix} \sim \begin{bmatrix} \mathbb{C}I & & \\ & \mathbb{M}_k & \\ & & \mathbb{C}I \end{bmatrix} + \begin{bmatrix} \mathcal{A}_{12} & \mathcal{A}_{13} \\ & \mathcal{A}_{23} \end{bmatrix} =: \mathcal{A}'$$

Idea: If \mathcal{A}' is not idempotent compressible, then no similarity $S^{-1}\mathcal{A}'S$ is projection compressible.

Theorem

Let \mathcal{A} be a unital subalgebra of \mathbb{M}_n .

Projection Compressibility?

$$\begin{bmatrix} \mathbb{C}I & ? & ? \\ & \mathbb{M}_k & ? \\ & & \mathbb{C}I \end{bmatrix} \sim \begin{bmatrix} \mathbb{C}I & & \\ & \mathbb{M}_k & \\ & & \mathbb{C}I \end{bmatrix} + \begin{bmatrix} \mathcal{A}_{12} & \mathcal{A}_{13} \\ & \mathcal{A}_{23} \end{bmatrix} =: \mathcal{A}'$$

Idea: If \mathcal{A}' is not idempotent compressible, then no similarity $S^{-1}\mathcal{A}'S$ is projection compressible.

Theorem

Let \mathcal{A} be a unital subalgebra of \mathbb{M}_n . If $\text{BlockDiag}(\mathcal{A})$ has a block of size ≥ 2 , then TFAE:

Projection Compressibility?

$$\begin{bmatrix} \mathbb{C}I & ? & ? \\ & \mathbb{M}_k & ? \\ & & \mathbb{C}I \end{bmatrix} \sim \begin{bmatrix} \mathbb{C}I & & \\ & \mathbb{M}_k & \\ & & \mathbb{C}I \end{bmatrix} + \begin{bmatrix} \mathcal{A}_{12} & \mathcal{A}_{13} \\ & \mathcal{A}_{23} \end{bmatrix} =: \mathcal{A}'$$

Idea: If \mathcal{A}' is not idempotent compressible, then no similarity $S^{-1}\mathcal{A}'S$ is projection compressible.

Theorem

Let \mathcal{A} be a unital subalgebra of \mathbb{M}_n . If $\text{BlockDiag}(\mathcal{A})$ has a block of size ≥ 2 , then TFAE:

- (i) \mathcal{A} is projection compressible;

Projection Compressibility?

$$\begin{bmatrix} \boxed{\mathbb{C}I} & ? & ? \\ & \boxed{M_k} & ? \\ & & \boxed{\mathbb{C}I} \end{bmatrix} \sim \begin{bmatrix} \boxed{\mathbb{C}I} & & \\ & \boxed{M_k} & \\ & & \boxed{\mathbb{C}I} \end{bmatrix} + \begin{bmatrix} \boxed{A_{12}} & \boxed{A_{13}} \\ & \boxed{A_{23}} \end{bmatrix} =: \mathcal{A}'$$

Idea: If \mathcal{A}' is not idempotent compressible, then no similarity $S^{-1}\mathcal{A}'S$ is projection compressible.

Theorem

Let \mathcal{A} be a unital subalgebra of \mathbb{M}_n . If $\text{BlockDiag}(\mathcal{A})$ has a block of size ≥ 2 , then TFAE:

- (i) \mathcal{A} is projection compressible;
- (ii) \mathcal{A} is idempotent compressible.

Projection Compressibility?

Projection Compressibility?

Theorem

*If \mathcal{A} is a unital, **semisimple** subalgebra of \mathbb{M}_n , then TFAE:*

Projection Compressibility?

Theorem

*If \mathcal{A} is a unital, **semisimple** subalgebra of \mathbb{M}_n , then TFAE:*

- (i) \mathcal{A} is projection compressible;*

Projection Compressibility?

Theorem

If \mathcal{A} is a unital, **semisimple** subalgebra of \mathbb{M}_n , then TFAE:

- (i) \mathcal{A} is projection compressible;
- (ii) \mathcal{A} is idempotent compressible;

Projection Compressibility?

Theorem

If \mathcal{A} is a unital, **semisimple** subalgebra of \mathbb{M}_n , then TFAE:

- (i) \mathcal{A} is projection compressible;
- (ii) \mathcal{A} is idempotent compressible;
- (iii) $\mathcal{A} = \mathcal{L} \cap \mathcal{R} + \mathbb{C}I$.

Projection Compressibility?

Theorem

If \mathcal{A} is a unital, **semisimple** subalgebra of \mathbb{M}_n , then TFAE:

- (i) \mathcal{A} is projection compressible;
- (ii) \mathcal{A} is idempotent compressible;
- (iii) $\mathcal{A} = \mathcal{L} \cap \mathcal{R} + \mathbb{C}I$.

Theorem

If \mathcal{A} is a unital subalgebra of \mathbb{M}_3 , then TFAE:

Projection Compressibility?

Theorem

If \mathcal{A} is a unital, **semisimple** subalgebra of \mathbb{M}_n , then TFAE:

- (i) \mathcal{A} is projection compressible;
- (ii) \mathcal{A} is idempotent compressible;
- (iii) $\mathcal{A} = \mathcal{L} \cap \mathcal{R} + \mathbb{C}I$.

Theorem

If \mathcal{A} is a unital subalgebra of \mathbb{M}_3 , then TFAE:

- (i) \mathcal{A} is projection compressible;

Projection Compressibility?

Theorem

If \mathcal{A} is a unital, **semisimple** subalgebra of \mathbb{M}_n , then TFAE:

- (i) \mathcal{A} is projection compressible;
- (ii) \mathcal{A} is idempotent compressible;
- (iii) $\mathcal{A} = \mathcal{L} \cap \mathcal{R} + \mathbb{C}I$.

Theorem

If \mathcal{A} is a unital subalgebra of \mathbb{M}_3 , then TFAE:

- (i) \mathcal{A} is projection compressible;
- (ii) \mathcal{A} is idempotent compressible.

Conclusion

Conclusion

Conjecture

Conclusion

Conjecture

A unital subalgebra \mathcal{A} of \mathbb{M}_n is projection compressible if and only if it is idempotent compressible.

Conclusion

Conjecture

A unital subalgebra \mathcal{A} of \mathbb{M}_n is projection compressible if and only if it is idempotent compressible.

Remaining:

Conclusion

Conjecture

A unital subalgebra \mathcal{A} of \mathbb{M}_n is projection compressible if and only if it is idempotent compressible.

Remaining:

$$\left[\begin{array}{|c|c|c|} \hline \mathbb{C}I & ? & ? \\ \hline & \alpha & ? \\ \hline & & \mathbb{C}I \\ \hline \end{array} \right]$$

Conclusion

Conjecture

A unital subalgebra \mathcal{A} of \mathbb{M}_n is projection compressible if and only if it is idempotent compressible.

Remaining:

$$\left[\begin{array}{|c|c|c|} \hline \mathbb{C}I & ? & ? \\ \hline & \alpha & ? \\ \hline & & \mathbb{C}I \\ \hline \end{array} \right], \quad \left[\begin{array}{|c|c|} \hline \mathbb{C}I & ? \\ \hline & \mathbb{C}I \\ \hline \end{array} \right]$$

THANK YOU!