

## §2.5 分块矩阵

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2016 - 2017 学年 I 暑修班

# 分块矩阵引入

- 矩阵

$$A = \begin{pmatrix} 1 & 0 & 0 & 3 \\ 0 & 1 & 0 & -1 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

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$$A = \begin{pmatrix} 1 & 0 & 0 & 3 \\ 0 & 1 & 0 & -1 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} = \left( \begin{array}{ccc|c} 1 & 0 & 0 & 3 \\ 0 & 1 & 0 & -1 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{array} \right)$$

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$$\equiv \begin{pmatrix} 1 & 0 & 0 & 3 \\ 0 & 1 & 0 & -1 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

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$$\equiv \left( \begin{array}{cc|cc} 1 & 0 & 0 & 3 \\ 0 & 1 & 0 & -1 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{array} \right) = \begin{pmatrix} & & & \\ & & & \\ & & & \\ & & & \end{pmatrix}$$

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$$\stackrel{or}{=} \left( \begin{array}{cc|cc} 1 & 0 & 0 & 3 \\ 0 & 1 & 0 & -1 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{array} \right) = \begin{pmatrix} I_2 & & \\ & I_2 & \end{pmatrix}$$

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# 分块矩阵

- 一般地，可将任意矩阵  $A$  作分割成若干子矩阵，例如

$$A = \begin{pmatrix} * & * & * & * & * & \cdots & * \\ * & * & * & * & * & \cdots & * \\ * & * & * & * & * & \cdots & * \\ * & * & * & * & * & \cdots & * \\ \vdots & \vdots & \vdots & \vdots & \vdots & \ddots & \vdots \\ * & * & * & * & * & \cdots & * \\ * & * & * & * & * & \cdots & * \end{pmatrix}$$

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$$A = \left( \begin{array}{cc|cc|c|c|c} * & * & * & * & * & \cdots & * \\ * & * & * & * & * & \cdots & * \\ * & * & * & * & * & \cdots & * \\ \hline * & * & * & * & * & \cdots & * \\ \hline \vdots & \vdots & \vdots & \vdots & \vdots & \ddots & \vdots \\ \hline * & * & * & * & * & \cdots & * \\ * & * & * & * & * & \cdots & * \end{array} \right)$$



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$$A = \begin{pmatrix} * & * & * & * & * & \cdots & * \\ * & * & * & * & * & \cdots & * \\ * & * & * & * & * & \cdots & * \\ \hline * & * & * & * & * & \cdots & * \\ \hline \vdots & \vdots & \vdots & \vdots & \vdots & \ddots & \vdots \\ \hline * & * & * & * & * & \cdots & * \\ * & * & * & * & * & \cdots & * \end{pmatrix} = \begin{pmatrix} A_{11} & A_{12} & & \\ & & & \end{pmatrix}$$

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称为分块矩阵。



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称为分块矩阵。

- 分块矩阵中
  - 每一行的每个子块有相同行数；
  - 每一列的每个子块有相同列数。

## 分块矩阵的运算：加法

假设矩阵  $A, B$  同型，且采取相同分块方式：

$$A = \begin{pmatrix} A_{11} & A_{12} & \cdots & A_{1t} \\ A_{21} & A_{22} & \cdots & A_{2t} \\ \vdots & \vdots & \ddots & \vdots \\ A_{s1} & A_{s2} & \cdots & A_{st} \end{pmatrix}, \quad B = \begin{pmatrix} B_{11} & B_{12} & \cdots & B_{1t} \\ B_{21} & B_{22} & \cdots & B_{2t} \\ \vdots & \vdots & \ddots & \vdots \\ B_{s1} & B_{s2} & \cdots & B_{st} \end{pmatrix}$$

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则

$$A + B =$$

## 分块矩阵的运算：加法

假设矩阵  $A, B$  同型，且采取相同分块方式：

$$A = \begin{pmatrix} A_{11} & A_{12} & \cdots & A_{1t} \\ A_{21} & A_{22} & \cdots & A_{2t} \\ \vdots & \vdots & \ddots & \vdots \\ A_{s1} & A_{s2} & \cdots & A_{st} \end{pmatrix} = (A_{pq}), \quad B = \begin{pmatrix} B_{11} & B_{12} & \cdots & B_{1t} \\ B_{21} & B_{22} & \cdots & B_{2t} \\ \vdots & \vdots & \ddots & \vdots \\ B_{s1} & B_{s2} & \cdots & B_{st} \end{pmatrix} = (B_{pq})$$

则

$$A + B = \begin{pmatrix} A_{11} + B_{11} & A_{12} + B_{12} & \cdots & A_{1t} + B_{1t} \\ A_{21} + B_{21} & A_{22} + B_{22} & \cdots & A_{2t} + B_{2t} \\ \vdots & \vdots & \ddots & \vdots \\ A_{s1} + B_{s1} & A_{s2} + B_{s2} & \cdots & A_{st} + B_{st} \end{pmatrix}$$

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$$A+B = \left( \begin{array}{cc|cc} 1 & 0 & 1 & 3 \\ 0 & 1 & 2 & 4 \\ \hline 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{array} \right) + \left( \begin{array}{cc|cc} 1 & 2 & 0 & 0 \\ 2 & 0 & 0 & 0 \\ \hline 6 & 3 & 1 & 0 \\ 0 & -2 & 0 & 1 \end{array} \right) = \left( \begin{array}{cc|cc} 2 & 2 & 1 & 3 \\ 2 & 1 & 2 & 4 \\ \hline 6 & 3 & 0 & 0 \\ 0 & -2 & 0 & 0 \end{array} \right)$$

或者

$$A+B = \left( \begin{array}{c|c} I & C \\ \hline O & -I \end{array} \right) + \left( \begin{array}{c|c} D & O \\ \hline F & I \end{array} \right) = \left( \begin{array}{c|c} I+D & C \\ \hline F & O \end{array} \right) = \left( \begin{array}{cc|cc} 2 & 2 & 1 & 3 \\ 2 & 1 & 2 & 4 \\ \hline 6 & 3 & 0 & 0 \\ 0 & -2 & 0 & 0 \end{array} \right)$$

## 分块矩阵的运算：数乘

$$A = \begin{pmatrix} A_{11} & A_{12} & \cdots & A_{1t} \\ A_{21} & A_{22} & \cdots & A_{2t} \\ \vdots & \vdots & \ddots & \vdots \\ A_{s1} & A_{s2} & \cdots & A_{st} \end{pmatrix} \Rightarrow kA =$$

## 分块矩阵的运算：数乘

$$A = \begin{pmatrix} A_{11} & A_{12} & \cdots & A_{1t} \\ A_{21} & A_{22} & \cdots & A_{2t} \\ \vdots & \vdots & \ddots & \vdots \\ A_{s1} & A_{s2} & \cdots & A_{st} \end{pmatrix} \Rightarrow kA = \begin{pmatrix} kA_{11} & kA_{12} & \cdots & kA_{1t} \\ kA_{21} & kA_{22} & \cdots & kA_{2t} \\ \vdots & \vdots & \ddots & \vdots \\ kA_{s1} & kA_{s2} & \cdots & kA_{st} \end{pmatrix}$$

## 分块矩阵的运算：数乘

$$A = \begin{pmatrix} A_{11} & A_{12} & \cdots & A_{1t} \\ A_{21} & A_{22} & \cdots & A_{2t} \\ \vdots & \vdots & \ddots & \vdots \\ A_{s1} & A_{s2} & \cdots & A_{st} \end{pmatrix} \Rightarrow kA = \begin{pmatrix} kA_{11} & kA_{12} & \cdots & kA_{1t} \\ kA_{21} & kA_{22} & \cdots & kA_{2t} \\ \vdots & \vdots & \ddots & \vdots \\ kA_{s1} & kA_{s2} & \cdots & kA_{st} \end{pmatrix}$$

例 设  $A = \begin{pmatrix} 1 & 0 & 1 & 3 \\ 0 & 1 & 2 & 4 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{pmatrix}$

## 分块矩阵的运算：数乘

$$A = \begin{pmatrix} A_{11} & A_{12} & \cdots & A_{1t} \\ A_{21} & A_{22} & \cdots & A_{2t} \\ \vdots & \vdots & \ddots & \vdots \\ A_{s1} & A_{s2} & \cdots & A_{st} \end{pmatrix} \Rightarrow kA = \begin{pmatrix} kA_{11} & kA_{12} & \cdots & kA_{1t} \\ kA_{21} & kA_{22} & \cdots & kA_{2t} \\ \vdots & \vdots & \ddots & \vdots \\ kA_{s1} & kA_{s2} & \cdots & kA_{st} \end{pmatrix}$$

例 设  $A = \left( \begin{array}{cc|cc} 1 & 0 & 1 & 3 \\ 0 & 1 & 2 & 4 \\ \hline 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{array} \right)$



## 分块矩阵的运算：数乘

$$A = \begin{pmatrix} A_{11} & A_{12} & \cdots & A_{1t} \\ A_{21} & A_{22} & \cdots & A_{2t} \\ \vdots & \vdots & \ddots & \vdots \\ A_{s1} & A_{s2} & \cdots & A_{st} \end{pmatrix} \Rightarrow kA = \begin{pmatrix} kA_{11} & kA_{12} & \cdots & kA_{1t} \\ kA_{21} & kA_{22} & \cdots & kA_{2t} \\ \vdots & \vdots & \ddots & \vdots \\ kA_{s1} & kA_{s2} & \cdots & kA_{st} \end{pmatrix}$$

例 设  $A = \left( \begin{array}{cc|cc} 1 & 0 & 1 & 3 \\ 0 & 1 & 2 & 4 \\ \hline 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{array} \right) = \left( \begin{array}{c|c} I & C \\ \hline O & -I \end{array} \right)$

## 分块矩阵的运算：数乘

$$A = \begin{pmatrix} A_{11} & A_{12} & \cdots & A_{1t} \\ A_{21} & A_{22} & \cdots & A_{2t} \\ \vdots & \vdots & \ddots & \vdots \\ A_{s1} & A_{s2} & \cdots & A_{st} \end{pmatrix} \Rightarrow kA = \begin{pmatrix} kA_{11} & kA_{12} & \cdots & kA_{1t} \\ kA_{21} & kA_{22} & \cdots & kA_{2t} \\ \vdots & \vdots & \ddots & \vdots \\ kA_{s1} & kA_{s2} & \cdots & kA_{st} \end{pmatrix}$$

例 设  $A = \left( \begin{array}{cc|cc} 1 & 0 & 1 & 3 \\ 0 & 1 & 2 & 4 \\ \hline 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{array} \right) = \left( \begin{array}{c|c} I & C \\ \hline O & -I \end{array} \right)$ , 则

$$kA =$$

## 分块矩阵的运算：数乘

$$A = \begin{pmatrix} A_{11} & A_{12} & \cdots & A_{1t} \\ A_{21} & A_{22} & \cdots & A_{2t} \\ \vdots & \vdots & \ddots & \vdots \\ A_{s1} & A_{s2} & \cdots & A_{st} \end{pmatrix} \Rightarrow kA = \begin{pmatrix} kA_{11} & kA_{12} & \cdots & kA_{1t} \\ kA_{21} & kA_{22} & \cdots & kA_{2t} \\ \vdots & \vdots & \ddots & \vdots \\ kA_{s1} & kA_{s2} & \cdots & kA_{st} \end{pmatrix}$$

例 设  $A = \left( \begin{array}{cc|cc} 1 & 0 & 1 & 3 \\ 0 & 1 & 2 & 4 \\ \hline 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{array} \right) = \left( \begin{array}{c|c} I & C \\ \hline O & -I \end{array} \right)$ , 则

$$kA = k \begin{pmatrix} I & C \\ O & -I \end{pmatrix} =$$

## 分块矩阵的运算：数乘

$$A = \begin{pmatrix} A_{11} & A_{12} & \cdots & A_{1t} \\ A_{21} & A_{22} & \cdots & A_{2t} \\ \vdots & \vdots & \ddots & \vdots \\ A_{s1} & A_{s2} & \cdots & A_{st} \end{pmatrix} \Rightarrow kA = \begin{pmatrix} kA_{11} & kA_{12} & \cdots & kA_{1t} \\ kA_{21} & kA_{22} & \cdots & kA_{2t} \\ \vdots & \vdots & \ddots & \vdots \\ kA_{s1} & kA_{s2} & \cdots & kA_{st} \end{pmatrix}$$

例 设  $A = \left( \begin{array}{cc|cc} 1 & 0 & 1 & 3 \\ 0 & 1 & 2 & 4 \\ \hline 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{array} \right) = \left( \begin{array}{c|c} I & C \\ \hline O & -I \end{array} \right)$ , 则

$$kA = k \begin{pmatrix} I & C \\ O & -I \end{pmatrix} = \begin{pmatrix} kI & kC \\ O & -kI \end{pmatrix} =$$

## 分块矩阵的运算：数乘

$$A = \begin{pmatrix} A_{11} & A_{12} & \cdots & A_{1t} \\ A_{21} & A_{22} & \cdots & A_{2t} \\ \vdots & \vdots & \ddots & \vdots \\ A_{s1} & A_{s2} & \cdots & A_{st} \end{pmatrix} \Rightarrow kA = \begin{pmatrix} kA_{11} & kA_{12} & \cdots & kA_{1t} \\ kA_{21} & kA_{22} & \cdots & kA_{2t} \\ \vdots & \vdots & \ddots & \vdots \\ kA_{s1} & kA_{s2} & \cdots & kA_{st} \end{pmatrix}$$

例 设  $A = \left( \begin{array}{cc|cc} 1 & 0 & 1 & 3 \\ 0 & 1 & 2 & 4 \\ \hline 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{array} \right) = \left( \begin{array}{c|c} I & C \\ \hline O & -I \end{array} \right)$ , 则

$$kA = k \left( \begin{array}{c|c} I & C \\ \hline O & -I \end{array} \right) = \left( \begin{array}{c|c} kI & kC \\ \hline O & -kI \end{array} \right) = \left( \begin{array}{c|c} \vdots & \vdots \\ \hline \vdots & \vdots \end{array} \right)$$

## 分块矩阵的运算：数乘

$$A = \begin{pmatrix} A_{11} & A_{12} & \cdots & A_{1t} \\ A_{21} & A_{22} & \cdots & A_{2t} \\ \vdots & \vdots & \ddots & \vdots \\ A_{s1} & A_{s2} & \cdots & A_{st} \end{pmatrix} \Rightarrow kA = \begin{pmatrix} kA_{11} & kA_{12} & \cdots & kA_{1t} \\ kA_{21} & kA_{22} & \cdots & kA_{2t} \\ \vdots & \vdots & \ddots & \vdots \\ kA_{s1} & kA_{s2} & \cdots & kA_{st} \end{pmatrix}$$

例 设  $A = \left( \begin{array}{cc|cc} 1 & 0 & 1 & 3 \\ 0 & 1 & 2 & 4 \\ \hline 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{array} \right) = \left( \begin{array}{c|c} I & C \\ \hline O & -I \end{array} \right)$ , 则

$$kA = k \left( \begin{array}{c|c} I & C \\ \hline O & -I \end{array} \right) = \left( \begin{array}{cc|cc} kI & kC & & \\ \hline O & -kI & & \end{array} \right)$$

## 分块矩阵的运算：数乘

$$A = \begin{pmatrix} A_{11} & A_{12} & \cdots & A_{1t} \\ A_{21} & A_{22} & \cdots & A_{2t} \\ \vdots & \vdots & \ddots & \vdots \\ A_{s1} & A_{s2} & \cdots & A_{st} \end{pmatrix} \Rightarrow kA = \begin{pmatrix} kA_{11} & kA_{12} & \cdots & kA_{1t} \\ kA_{21} & kA_{22} & \cdots & kA_{2t} \\ \vdots & \vdots & \ddots & \vdots \\ kA_{s1} & kA_{s2} & \cdots & kA_{st} \end{pmatrix}$$

例 设  $A = \left( \begin{array}{cc|cc} 1 & 0 & 1 & 3 \\ 0 & 1 & 2 & 4 \\ \hline 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{array} \right) = \left( \begin{array}{c|c} I & C \\ \hline O & -I \end{array} \right)$ , 则

$$kA = k \left( \begin{array}{c|c} I & C \\ \hline O & -I \end{array} \right) = \left( \begin{array}{cc|cc} k & 0 & k & 3k \\ 0 & k & 2k & 4k \\ \hline \vdots & \vdots & \vdots & \vdots \\ k & 0 & 0 & -k \end{array} \right)$$

## 分块矩阵的运算：数乘

$$A = \begin{pmatrix} A_{11} & A_{12} & \cdots & A_{1t} \\ A_{21} & A_{22} & \cdots & A_{2t} \\ \vdots & \vdots & \ddots & \vdots \\ A_{s1} & A_{s2} & \cdots & A_{st} \end{pmatrix} \Rightarrow kA = \begin{pmatrix} kA_{11} & kA_{12} & \cdots & kA_{1t} \\ kA_{21} & kA_{22} & \cdots & kA_{2t} \\ \vdots & \vdots & \ddots & \vdots \\ kA_{s1} & kA_{s2} & \cdots & kA_{st} \end{pmatrix}$$

例 设  $A = \left( \begin{array}{cc|cc} 1 & 0 & 1 & 3 \\ 0 & 1 & 2 & 4 \\ \hline 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{array} \right) = \left( \begin{array}{c|c} I & C \\ \hline O & -I \end{array} \right)$ , 则

$$kA = k \left( \begin{array}{c|c} I & C \\ \hline O & -I \end{array} \right) = \left( \begin{array}{cc|cc} k & 0 & k & 3k \\ 0 & k & 2k & 4k \\ \hline 0 & 0 & -k & 0 \\ 0 & 0 & 0 & -k \end{array} \right)$$



## 分块矩阵的运算：数乘

$$A = \begin{pmatrix} A_{11} & A_{12} & \cdots & A_{1t} \\ A_{21} & A_{22} & \cdots & A_{2t} \\ \vdots & \vdots & \ddots & \vdots \\ A_{s1} & A_{s2} & \cdots & A_{st} \end{pmatrix} \Rightarrow kA = \begin{pmatrix} kA_{11} & kA_{12} & \cdots & kA_{1t} \\ kA_{21} & kA_{22} & \cdots & kA_{2t} \\ \vdots & \vdots & \ddots & \vdots \\ kA_{s1} & kA_{s2} & \cdots & kA_{st} \end{pmatrix}$$

例 设  $A = \left( \begin{array}{cc|cc} 1 & 0 & 1 & 3 \\ 0 & 1 & 2 & 4 \\ \hline 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{array} \right) = \left( \begin{array}{c|c} I & C \\ \hline O & -I \end{array} \right)$ , 则

$$kA = k \left( \begin{array}{c|c} I & C \\ \hline O & -I \end{array} \right) = \left( \begin{array}{cc|cc} k & 0 & k & 3k \\ 0 & k & 2k & 4k \\ \hline 0 & 0 & -k & 0 \\ 0 & 0 & 0 & -k \end{array} \right)$$

# 分块矩阵的运算：乘积

假设将矩阵  $A_{m \times l}$ ,  $B_{l \times n}$  分块为

$$A = \begin{pmatrix} A_{11} & A_{12} & \cdots & A_{1r} \\ A_{21} & A_{22} & \cdots & A_{2r} \\ \vdots & \vdots & \ddots & \vdots \\ A_{s1} & A_{s2} & \cdots & A_{sr} \end{pmatrix}, \quad B = \begin{pmatrix} B_{11} & B_{12} & \cdots & B_{1t} \\ B_{21} & B_{22} & \cdots & B_{2t} \\ \vdots & \vdots & \ddots & \vdots \\ B_{r1} & B_{r2} & \cdots & B_{rt} \end{pmatrix}$$

## 分块矩阵的运算：乘积

假设将矩阵  $A_{m \times l}$ ,  $B_{l \times n}$  分块为

$$A = \begin{pmatrix} A_{11} & A_{12} & \cdots & A_{1r} \\ A_{21} & A_{22} & \cdots & A_{2r} \\ \vdots & \vdots & \ddots & \vdots \\ A_{s1} & A_{s2} & \cdots & A_{sr} \end{pmatrix}, \quad B = \begin{pmatrix} B_{11} & B_{12} & \cdots & B_{1t} \\ B_{21} & B_{22} & \cdots & B_{2t} \\ \vdots & \vdots & \ddots & \vdots \\ B_{r1} & B_{r2} & \cdots & B_{rt} \end{pmatrix}$$

则

$$AB = C =$$

## 分块矩阵的运算：乘积

假设将矩阵  $A_{m \times l}$ ,  $B_{l \times n}$  分块为

$$A = \begin{pmatrix} A_{11} & A_{12} & \cdots & A_{1r} \\ A_{21} & A_{22} & \cdots & A_{2r} \\ \vdots & \vdots & \ddots & \vdots \\ A_{s1} & A_{s2} & \cdots & A_{sr} \end{pmatrix}, \quad B = \begin{pmatrix} B_{11} & B_{12} & \cdots & B_{1t} \\ B_{21} & B_{22} & \cdots & B_{2t} \\ \vdots & \vdots & \ddots & \vdots \\ B_{r1} & B_{r2} & \cdots & B_{rt} \end{pmatrix}$$

则

$$AB = C = (C_{pq})$$

## 分块矩阵的运算：乘积

假设将矩阵  $A_{m \times l}$ ,  $B_{l \times n}$  分块为

$$A = \begin{pmatrix} A_{11} & A_{12} & \cdots & A_{1r} \\ A_{21} & A_{22} & \cdots & A_{2r} \\ \vdots & \vdots & \ddots & \vdots \\ A_{s1} & A_{s2} & \cdots & A_{sr} \end{pmatrix}, \quad B = \begin{pmatrix} B_{11} & B_{12} & \cdots & B_{1t} \\ B_{21} & B_{22} & \cdots & B_{2t} \\ \vdots & \vdots & \ddots & \vdots \\ B_{r1} & B_{r2} & \cdots & B_{rt} \end{pmatrix}$$

则

$$AB = C = (C_{pq})$$

其中

$$C_{pq} = \quad .$$

## 分块矩阵的运算：乘积

假设将矩阵  $A_{m \times l}$ ,  $B_{l \times n}$  分块为

$$A = \begin{pmatrix} A_{11} & A_{12} & \cdots & A_{1r} \\ A_{21} & A_{22} & \cdots & A_{2r} \\ \vdots & \vdots & \ddots & \vdots \\ A_{s1} & A_{s2} & \cdots & A_{sr} \end{pmatrix}, \quad B = \begin{pmatrix} B_{11} & B_{12} & \cdots & B_{1t} \\ B_{21} & B_{22} & \cdots & B_{2t} \\ \vdots & \vdots & \ddots & \vdots \\ B_{r1} & B_{r2} & \cdots & B_{rt} \end{pmatrix}$$

则

$$AB = C = (C_{pq})$$

其中

$$C_{pq} = A_{p1} \quad A_{p2} \quad \cdots \quad A_{pr} \quad .$$

## 分块矩阵的运算：乘积

假设将矩阵  $A_{m \times l}$ ,  $B_{l \times n}$  分块为

$$A = \begin{pmatrix} A_{11} & A_{12} & \cdots & A_{1r} \\ A_{21} & A_{22} & \cdots & A_{2r} \\ \vdots & \vdots & \ddots & \vdots \\ A_{s1} & A_{s2} & \cdots & A_{sr} \end{pmatrix}, \quad B = \begin{pmatrix} B_{11} & B_{12} & \cdots & B_{1t} \\ B_{21} & B_{22} & \cdots & B_{2t} \\ \vdots & \vdots & \ddots & \vdots \\ B_{r1} & B_{r2} & \cdots & B_{rt} \end{pmatrix}$$

则

$$AB = C = (C_{pq})$$

其中

$$C_{pq} = A_{p1}B_{1q} \quad A_{p2}B_{2q} \quad \cdots \quad A_{pr}B_{rq}.$$

## 分块矩阵的运算：乘积

假设将矩阵  $A_{m \times l}$ ,  $B_{l \times n}$  分块为

$$A = \begin{pmatrix} A_{11} & A_{12} & \cdots & A_{1r} \\ A_{21} & A_{22} & \cdots & A_{2r} \\ \vdots & \vdots & \ddots & \vdots \\ A_{s1} & A_{s2} & \cdots & A_{sr} \end{pmatrix}, \quad B = \begin{pmatrix} B_{11} & B_{12} & \cdots & B_{1t} \\ B_{21} & B_{22} & \cdots & B_{2t} \\ \vdots & \vdots & \ddots & \vdots \\ B_{r1} & B_{r2} & \cdots & B_{rt} \end{pmatrix}$$

则

$$AB = C = (C_{pq})$$

其中

$$C_{pq} = A_{p1}B_{1q} + A_{p2}B_{2q} + \cdots + A_{pr}B_{rq}.$$



## 分块矩阵的运算：乘积

假设将矩阵  $A_{m \times l}$ ,  $B_{l \times n}$  分块为

$$A = \begin{pmatrix} A_{11} & A_{12} & \cdots & A_{1r} \\ A_{21} & A_{22} & \cdots & A_{2r} \\ \vdots & \vdots & \ddots & \vdots \\ A_{s1} & A_{s2} & \cdots & A_{sr} \end{pmatrix}, \quad B = \begin{pmatrix} B_{11} & B_{12} & \cdots & B_{1t} \\ B_{21} & B_{22} & \cdots & B_{2t} \\ \vdots & \vdots & \ddots & \vdots \\ B_{r1} & B_{r2} & \cdots & B_{rt} \end{pmatrix}$$

则

$$AB = C = (C_{pq})$$

其中（假设每个子块的乘积有意义）

$$C_{pq} = A_{p1}B_{1q} + A_{p2}B_{2q} + \cdots + A_{pr}B_{rq}.$$

## 分块矩阵的运算：乘积

假设将矩阵  $A_{m \times l}$ ,  $B_{l \times n}$  分块为

$$A = \begin{pmatrix} A_{11} & A_{12} & \cdots & A_{1r} \\ A_{21} & A_{22} & \cdots & A_{2r} \\ \vdots & \vdots & \ddots & \vdots \\ A_{s1} & A_{s2} & \cdots & A_{sr} \end{pmatrix}, \quad B = \begin{pmatrix} B_{11} & B_{12} & \cdots & B_{1t} \\ B_{21} & B_{22} & \cdots & B_{2t} \\ \vdots & \vdots & \ddots & \vdots \\ B_{r1} & B_{r2} & \cdots & B_{rt} \end{pmatrix}$$

则

$$AB = C = (C_{pq})$$

其中（假设每个子块的乘积有意义）

$$C_{pq} = A_{p1}B_{1q} + A_{p2}B_{2q} + \cdots + A_{pr}B_{rq}.$$

$$\begin{pmatrix} A_{11} & \cdots & A_{1r} \\ \vdots & & \vdots \\ A_{p1} & \cdots & A_{pr} \\ \vdots & & \vdots \\ A_{s1} & \cdots & A_{sr} \end{pmatrix} \cdot \begin{pmatrix} B_{11} & \cdots & B_{1q} & \cdots & B_{1t} \\ \vdots & & \vdots & & \vdots \\ B_{r1} & \cdots & B_{rq} & \cdots & B_{rt} \end{pmatrix} = \begin{pmatrix} C_{11} & \cdots & \cdots & C_{1t} \\ \vdots & & \vdots & \vdots \\ \cdots & C_{pq} & \cdots & \vdots \\ \vdots & & \vdots & \vdots \\ C_{s1} & \cdots & \cdots & C_{st} \end{pmatrix}$$

## 分块矩阵的运算：乘积

假设将矩阵  $A_{m \times l}$ ,  $B_{l \times n}$  分块为

$$A = \begin{pmatrix} A_{11} & A_{12} & \cdots & A_{1r} \\ A_{21} & A_{22} & \cdots & A_{2r} \\ \vdots & \vdots & \ddots & \vdots \\ A_{s1} & A_{s2} & \cdots & A_{sr} \end{pmatrix}, \quad B = \begin{pmatrix} B_{11} & B_{12} & \cdots & B_{1t} \\ B_{21} & B_{22} & \cdots & B_{2t} \\ \vdots & \vdots & \ddots & \vdots \\ B_{r1} & B_{r2} & \cdots & B_{rt} \end{pmatrix}$$

则

$$AB = C = (C_{pq})$$

其中（假设每个子块的乘积有意义）

$$C_{pq} = A_{p1}B_{1q} + A_{p2}B_{2q} + \cdots + A_{pr}B_{rq}.$$

$$\begin{pmatrix} A_{11} & \cdots & A_{1r} \\ \vdots & & \vdots \\ A_{p1} & \cdots & A_{pr} \\ \vdots & & \vdots \\ A_{s1} & \cdots & A_{sr} \end{pmatrix} \cdot \begin{pmatrix} B_{11} & \cdots & B_{1q} & \cdots & B_{1t} \\ \vdots & & \vdots & & \vdots \\ B_{r1} & \cdots & B_{rq} & \cdots & B_{rt} \end{pmatrix} = \begin{pmatrix} C_{11} & \cdots & \cdots & C_{1t} \\ \vdots & & \vdots & \\ & \cdots & C_{pq} & \cdots \\ \vdots & & \vdots & \\ C_{s1} & \cdots & \cdots & C_{st} \end{pmatrix}$$

## 分块矩阵的运算：乘积

假设将矩阵  $A_{m \times l}$ ,  $B_{l \times n}$  分块为

$$A = \begin{pmatrix} A_{11} & A_{12} & \cdots & A_{1r} \\ A_{21} & A_{22} & \cdots & A_{2r} \\ \vdots & \vdots & \ddots & \vdots \\ A_{s1} & A_{s2} & \cdots & A_{sr} \end{pmatrix}, \quad B = \begin{pmatrix} B_{11} & B_{12} & \cdots & B_{1t} \\ B_{21} & B_{22} & \cdots & B_{2t} \\ \vdots & \vdots & \ddots & \vdots \\ B_{r1} & B_{r2} & \cdots & B_{rt} \end{pmatrix}$$

则

$$AB = C = (C_{pq})$$

其中（假设每个子块的乘积有意义）

$$C_{pq} = A_{p1}B_{1q} + A_{p2}B_{2q} + \cdots + A_{pr}B_{rq}.$$

$$\begin{pmatrix} A_{11} & \cdots & A_{1r} \\ \vdots & & \vdots \\ A_{p1} & \cdots & A_{pr} \\ \vdots & & \vdots \\ A_{s1} & \cdots & A_{sr} \end{pmatrix} \cdot \begin{pmatrix} B_{11} & \cdots & B_{1q} & \cdots & B_{1t} \\ \vdots & & \vdots & & \vdots \\ B_{r1} & \cdots & B_{rq} & \cdots & B_{rt} \end{pmatrix} = \begin{pmatrix} C_{11} & \cdots & \cdots & C_{1t} \\ \vdots & & \vdots & \\ \vdots & \cdots & C_{pq} & \cdots \\ \vdots & & \vdots & \\ C_{s1} & \cdots & \vdots & \cdots & C_{st} \end{pmatrix}$$

## 分块矩阵的运算：乘积

例 设  $A = \begin{pmatrix} 1 & 0 & 1 & 3 \\ 0 & 1 & 2 & 4 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{pmatrix}$

,  $B = \begin{pmatrix} 1 & 2 & 0 & 0 \\ 2 & 0 & 0 & 0 \\ 6 & 3 & 1 & 0 \\ 0 & -2 & 0 & 1 \end{pmatrix}$

则

$$AB =$$

## 分块矩阵的运算：乘积

例 设  $A = \left( \begin{array}{cc|cc} 1 & 0 & 1 & 3 \\ 0 & 1 & 2 & 4 \\ \hline 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{array} \right) = \left( \begin{array}{c|c} I & C \\ \hline O & -I \end{array} \right), B = \begin{pmatrix} 1 & 2 & 0 & 0 \\ 2 & 0 & 0 & 0 \\ 6 & 3 & 1 & 0 \\ 0 & -2 & 0 & 1 \end{pmatrix}$

则

$$AB =$$

## 分块矩阵的运算：乘积

例 设  $A = \left( \begin{array}{cc|cc} 1 & 0 & 1 & 3 \\ 0 & 1 & 2 & 4 \\ \hline 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{array} \right) = \left( \begin{array}{c|c} I & C \\ \hline O & -I \end{array} \right), \quad B = \left( \begin{array}{cc|cc} 1 & 2 & 0 & 0 \\ 2 & 0 & 0 & 0 \\ \hline 6 & 3 & 1 & 0 \\ 0 & -2 & 0 & 1 \end{array} \right) = \left( \begin{array}{c|c} D & O \\ \hline F & I \end{array} \right)$

则

$$AB =$$

## 分块矩阵的运算：乘积

例 设  $A = \left( \begin{array}{cc|cc} 1 & 0 & 1 & 3 \\ 0 & 1 & 2 & 4 \\ \hline 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{array} \right) = \left( \begin{array}{c|c} I & C \\ \hline O & -I \end{array} \right), \quad B = \left( \begin{array}{cc|cc} 1 & 2 & 0 & 0 \\ 2 & 0 & 0 & 0 \\ \hline 6 & 3 & 1 & 0 \\ 0 & -2 & 0 & 1 \end{array} \right) = \left( \begin{array}{c|c} D & O \\ \hline F & I \end{array} \right)$

则

$$AB = \left( \begin{array}{c|c} I & C \\ \hline O & -I \end{array} \right) \left( \begin{array}{c|c} D & O \\ \hline F & I \end{array} \right) =$$



## 分块矩阵的运算：乘积

例 设  $A = \left( \begin{array}{cc|cc} 1 & 0 & 1 & 3 \\ 0 & 1 & 2 & 4 \\ \hline 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{array} \right) = \left( \begin{array}{c|c} I & C \\ \hline O & -I \end{array} \right), \quad B = \left( \begin{array}{cc|cc} 1 & 2 & 0 & 0 \\ 2 & 0 & 0 & 0 \\ \hline 6 & 3 & 1 & 0 \\ 0 & -2 & 0 & 1 \end{array} \right) = \left( \begin{array}{c|c} D & O \\ \hline F & I \end{array} \right)$

则

$$AB = \left( \begin{array}{c|c} I & C \\ \hline O & -I \end{array} \right) \left( \begin{array}{c|c} D & O \\ \hline F & I \end{array} \right) = \left( \begin{array}{c|c} & \\ \hline & \end{array} \right)$$

## 分块矩阵的运算：乘积

例 设  $A = \left( \begin{array}{cc|cc} 1 & 0 & 1 & 3 \\ 0 & 1 & 2 & 4 \\ \hline 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{array} \right) = \left( \begin{array}{c|c} I & C \\ \hline O & -I \end{array} \right), \quad B = \left( \begin{array}{cc|cc} 1 & 2 & 0 & 0 \\ 2 & 0 & 0 & 0 \\ \hline 6 & 3 & 1 & 0 \\ 0 & -2 & 0 & 1 \end{array} \right) = \left( \begin{array}{c|c} D & O \\ \hline F & I \end{array} \right)$

则

$$AB = \left( \begin{array}{c|c} I & C \\ \hline O & -I \end{array} \right) \left( \begin{array}{c|c} D & O \\ \hline F & I \end{array} \right) = \left( \begin{array}{cc} ID + CF & \\ & \end{array} \right)$$

## 分块矩阵的运算：乘积

例 设  $A = \left( \begin{array}{cc|cc} 1 & 0 & 1 & 3 \\ 0 & 1 & 2 & 4 \\ \hline 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{array} \right) = \left( \begin{array}{c|c} I & C \\ \hline O & -I \end{array} \right), \quad B = \left( \begin{array}{cc|cc} 1 & 2 & 0 & 0 \\ 2 & 0 & 0 & 0 \\ \hline 6 & 3 & 1 & 0 \\ 0 & -2 & 0 & 1 \end{array} \right) = \left( \begin{array}{c|c} D & O \\ \hline F & I \end{array} \right)$

则

$$AB = \left( \begin{array}{c|c} I & C \\ \hline O & -I \end{array} \right) \left( \begin{array}{c|c} D & O \\ \hline F & I \end{array} \right) = \left( \begin{array}{cc} ID + CF & IO + CI \end{array} \right)$$

## 分块矩阵的运算：乘积

例 设  $A = \left( \begin{array}{cc|cc} 1 & 0 & 1 & 3 \\ 0 & 1 & 2 & 4 \\ \hline 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{array} \right) = \left( \begin{array}{c|c} I & C \\ \hline O & -I \end{array} \right), \quad B = \left( \begin{array}{cc|cc} 1 & 2 & 0 & 0 \\ 2 & 0 & 0 & 0 \\ \hline 6 & 3 & 1 & 0 \\ 0 & -2 & 0 & 1 \end{array} \right) = \left( \begin{array}{c|c} D & O \\ \hline F & I \end{array} \right)$

则

$$AB = \begin{pmatrix} I & C \\ O & -I \end{pmatrix} \begin{pmatrix} D & O \\ F & I \end{pmatrix} = \begin{pmatrix} ID + CF & IO + CI \\ OD + (-I)F & \end{pmatrix}$$

## 分块矩阵的运算：乘积

例 设  $A = \left( \begin{array}{cc|cc} 1 & 0 & 1 & 3 \\ 0 & 1 & 2 & 4 \\ \hline 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{array} \right) = \left( \begin{array}{c|c} I & C \\ \hline O & -I \end{array} \right), \quad B = \left( \begin{array}{cc|cc} 1 & 2 & 0 & 0 \\ 2 & 0 & 0 & 0 \\ \hline 6 & 3 & 1 & 0 \\ 0 & -2 & 0 & 1 \end{array} \right) = \left( \begin{array}{c|c} D & O \\ \hline F & I \end{array} \right)$

则

$$AB = \begin{pmatrix} I & C \\ O & -I \end{pmatrix} \begin{pmatrix} D & O \\ F & I \end{pmatrix} = \begin{pmatrix} ID + CF & IO + CI \\ OD + (-I)F & OO + (-I)I \end{pmatrix}$$

## 分块矩阵的运算：乘积

例 设  $A = \left( \begin{array}{cc|cc} 1 & 0 & 1 & 3 \\ 0 & 1 & 2 & 4 \\ \hline 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{array} \right) = \left( \begin{array}{c|c} I & C \\ \hline O & -I \end{array} \right), \quad B = \left( \begin{array}{cc|cc} 1 & 2 & 0 & 0 \\ 2 & 0 & 0 & 0 \\ \hline 6 & 3 & 1 & 0 \\ 0 & -2 & 0 & 1 \end{array} \right) = \left( \begin{array}{c|c} D & O \\ \hline F & I \end{array} \right)$

则

$$\begin{aligned} AB &= \begin{pmatrix} I & C \\ O & -I \end{pmatrix} \begin{pmatrix} D & O \\ F & I \end{pmatrix} = \begin{pmatrix} ID + CF & IO + CI \\ OD + (-I)F & OO + (-I)I \end{pmatrix} \\ &= \begin{pmatrix} & \\ & \end{pmatrix} = \end{aligned}$$

## 分块矩阵的运算：乘积

例 设  $A = \left( \begin{array}{cc|cc} 1 & 0 & 1 & 3 \\ 0 & 1 & 2 & 4 \\ \hline 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{array} \right) = \left( \begin{array}{c|c} I & C \\ \hline O & -I \end{array} \right), \quad B = \left( \begin{array}{cc|cc} 1 & 2 & 0 & 0 \\ 2 & 0 & 0 & 0 \\ \hline 6 & 3 & 1 & 0 \\ 0 & -2 & 0 & 1 \end{array} \right) = \left( \begin{array}{c|c} D & O \\ \hline F & I \end{array} \right)$

则

$$\begin{aligned} AB &= \begin{pmatrix} I & C \\ O & -I \end{pmatrix} \begin{pmatrix} D & O \\ F & I \end{pmatrix} = \begin{pmatrix} ID + CF & IO + CI \\ OD + (-I)F & OO + (-I)I \end{pmatrix} \\ &= \begin{pmatrix} D + CF & \\ & \end{pmatrix} = \end{aligned}$$

## 分块矩阵的运算：乘积

例 设  $A = \left( \begin{array}{cc|cc} 1 & 0 & 1 & 3 \\ 0 & 1 & 2 & 4 \\ \hline 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{array} \right) = \left( \begin{array}{c|c} I & C \\ \hline O & -I \end{array} \right), \quad B = \left( \begin{array}{cc|cc} 1 & 2 & 0 & 0 \\ 2 & 0 & 0 & 0 \\ \hline 6 & 3 & 1 & 0 \\ 0 & -2 & 0 & 1 \end{array} \right) = \left( \begin{array}{c|c} D & O \\ \hline F & I \end{array} \right)$

则

$$\begin{aligned} AB &= \begin{pmatrix} I & C \\ O & -I \end{pmatrix} \begin{pmatrix} D & O \\ F & I \end{pmatrix} = \begin{pmatrix} ID + CF & IO + CI \\ OD + (-I)F & OO + (-I)I \end{pmatrix} \\ &= \begin{pmatrix} D + CF & C \\ \hline \end{pmatrix} = \end{aligned}$$



## 分块矩阵的运算：乘积

例 设  $A = \left( \begin{array}{cc|cc} 1 & 0 & 1 & 3 \\ 0 & 1 & 2 & 4 \\ \hline 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{array} \right) = \left( \begin{array}{c|c} I & C \\ \hline O & -I \end{array} \right), \quad B = \left( \begin{array}{cc|cc} 1 & 2 & 0 & 0 \\ 2 & 0 & 0 & 0 \\ \hline 6 & 3 & 1 & 0 \\ 0 & -2 & 0 & 1 \end{array} \right) = \left( \begin{array}{c|c} D & O \\ \hline F & I \end{array} \right)$

则

$$\begin{aligned} AB &= \begin{pmatrix} I & C \\ O & -I \end{pmatrix} \begin{pmatrix} D & O \\ F & I \end{pmatrix} = \begin{pmatrix} ID + CF & IO + CI \\ OD + (-I)F & OO + (-I)I \end{pmatrix} \\ &= \begin{pmatrix} D + CF & C \\ -F & \end{pmatrix} = \end{aligned}$$

## 分块矩阵的运算：乘积

例 设  $A = \left( \begin{array}{cc|cc} 1 & 0 & 1 & 3 \\ 0 & 1 & 2 & 4 \\ \hline 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{array} \right) = \left( \begin{array}{c|c} I & C \\ \hline O & -I \end{array} \right), \quad B = \left( \begin{array}{cc|cc} 1 & 2 & 0 & 0 \\ 2 & 0 & 0 & 0 \\ \hline 6 & 3 & 1 & 0 \\ 0 & -2 & 0 & 1 \end{array} \right) = \left( \begin{array}{c|c} D & O \\ \hline F & I \end{array} \right)$

则

$$\begin{aligned} AB &= \begin{pmatrix} I & C \\ O & -I \end{pmatrix} \begin{pmatrix} D & O \\ F & I \end{pmatrix} = \begin{pmatrix} ID + CF & IO + CI \\ OD + (-I)F & OO + (-I)I \end{pmatrix} \\ &= \begin{pmatrix} D + CF & C \\ -F & -I \end{pmatrix} = \end{aligned}$$

## 分块矩阵的运算：乘积

例 设  $A = \left( \begin{array}{cc|cc} 1 & 0 & 1 & 3 \\ 0 & 1 & 2 & 4 \\ \hline 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{array} \right) = \left( \begin{array}{c|c} I & C \\ \hline O & -I \end{array} \right), B = \left( \begin{array}{cc|cc} 1 & 2 & 0 & 0 \\ 2 & 0 & 0 & 0 \\ \hline 6 & 3 & 1 & 0 \\ 0 & -2 & 0 & 1 \end{array} \right) = \left( \begin{array}{c|c} D & O \\ \hline F & I \end{array} \right)$

则

$$\begin{aligned} AB &= \begin{pmatrix} I & C \\ O & -I \end{pmatrix} \begin{pmatrix} D & O \\ F & I \end{pmatrix} = \begin{pmatrix} ID + CF & IO + CI \\ OD + (-I)F & OO + (-I)I \end{pmatrix} \\ &= \begin{pmatrix} D + CF & C \\ -F & -I \end{pmatrix} = \left( \begin{array}{cc|cc} & & & \\ & & & \\ \hline & & & \\ & & & \end{array} \right) \end{aligned}$$

## 分块矩阵的运算：乘积

例 设  $A = \left( \begin{array}{cc|cc} 1 & 0 & 1 & 3 \\ 0 & 1 & 2 & 4 \\ \hline 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{array} \right) = \left( \begin{array}{c|c} I & C \\ \hline O & -I \end{array} \right), B = \left( \begin{array}{cc|cc} 1 & 2 & 0 & 0 \\ 2 & 0 & 0 & 0 \\ \hline 6 & 3 & 1 & 0 \\ 0 & -2 & 0 & 1 \end{array} \right) = \left( \begin{array}{c|c} D & O \\ \hline F & I \end{array} \right)$

则

$$\begin{aligned} AB &= \begin{pmatrix} I & C \\ O & -I \end{pmatrix} \begin{pmatrix} D & O \\ F & I \end{pmatrix} = \begin{pmatrix} ID + CF & IO + CI \\ OD + (-I)F & OO + (-I)I \end{pmatrix} \\ &= \begin{pmatrix} D + CF & C \\ -F & -I \end{pmatrix} = \left( \begin{array}{cc|cc} & & 1 & 3 \\ & & 2 & 4 \\ \hline & & & \\ & & & \end{array} \right) \end{aligned}$$

## 分块矩阵的运算：乘积

例 设  $A = \left( \begin{array}{cc|cc} 1 & 0 & 1 & 3 \\ 0 & 1 & 2 & 4 \\ \hline 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{array} \right) = \left( \begin{array}{c|c} I & C \\ \hline O & -I \end{array} \right), \quad B = \left( \begin{array}{cc|cc} 1 & 2 & 0 & 0 \\ 2 & 0 & 0 & 0 \\ \hline 6 & 3 & 1 & 0 \\ 0 & -2 & 0 & 1 \end{array} \right) = \left( \begin{array}{c|c} D & O \\ \hline F & I \end{array} \right)$

则

$$\begin{aligned} AB &= \begin{pmatrix} I & C \\ O & -I \end{pmatrix} \begin{pmatrix} D & O \\ F & I \end{pmatrix} = \begin{pmatrix} ID + CF & IO + CI \\ OD + (-I)F & OO + (-I)I \end{pmatrix} \\ &= \begin{pmatrix} D + CF & C \\ -F & -I \end{pmatrix} = \left( \begin{array}{cc|cc} & & 1 & 3 \\ & & 2 & 4 \\ \hline -6 & -3 & & \\ 0 & 2 & & \end{array} \right) \end{aligned}$$

## 分块矩阵的运算：乘积

例 设  $A = \left( \begin{array}{cc|cc} 1 & 0 & 1 & 3 \\ 0 & 1 & 2 & 4 \\ \hline 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{array} \right) = \left( \begin{array}{c|c} I & C \\ \hline O & -I \end{array} \right), \quad B = \left( \begin{array}{cc|cc} 1 & 2 & 0 & 0 \\ 2 & 0 & 0 & 0 \\ \hline 6 & 3 & 1 & 0 \\ 0 & -2 & 0 & 1 \end{array} \right) = \left( \begin{array}{c|c} D & O \\ \hline F & I \end{array} \right)$

则

$$\begin{aligned} AB &= \begin{pmatrix} I & C \\ O & -I \end{pmatrix} \begin{pmatrix} D & O \\ F & I \end{pmatrix} = \begin{pmatrix} ID + CF & IO + CI \\ OD + (-I)F & OO + (-I)I \end{pmatrix} \\ &= \begin{pmatrix} D + CF & C \\ -F & -I \end{pmatrix} = \left( \begin{array}{cc|cc} & & 1 & 3 \\ & & 2 & 4 \\ \hline -6 & -3 & -1 & 0 \\ 0 & 2 & 0 & -1 \end{array} \right) \end{aligned}$$

## 分块矩阵的运算：乘积

例 设  $A = \left( \begin{array}{cc|cc} 1 & 0 & 1 & 3 \\ 0 & 1 & 2 & 4 \\ \hline 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{array} \right) = \left( \begin{array}{c|c} I & C \\ \hline O & -I \end{array} \right), B = \left( \begin{array}{cc|cc} 1 & 2 & 0 & 0 \\ 2 & 0 & 0 & 0 \\ \hline 6 & 3 & 1 & 0 \\ 0 & -2 & 0 & 1 \end{array} \right) = \left( \begin{array}{c|c} D & O \\ \hline F & I \end{array} \right)$

则

$$\begin{aligned} AB &= \begin{pmatrix} I & C \\ O & -I \end{pmatrix} \begin{pmatrix} D & O \\ F & I \end{pmatrix} = \begin{pmatrix} ID + CF & IO + CI \\ OD + (-I)F & OO + (-I)I \end{pmatrix} \\ &= \begin{pmatrix} D + CF & C \\ -F & -I \end{pmatrix} = \left( \begin{array}{cc|cc} & & 1 & 3 \\ & & 2 & 4 \\ \hline -6 & -3 & -1 & 0 \\ 0 & 2 & 0 & -1 \end{array} \right) \end{aligned}$$

其中

$$D + CF =$$

## 分块矩阵的运算：乘积

例 设  $A = \left( \begin{array}{cc|cc} 1 & 0 & 1 & 3 \\ 0 & 1 & 2 & 4 \\ \hline 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{array} \right) = \left( \begin{array}{c|c} I & C \\ \hline O & -I \end{array} \right), B = \left( \begin{array}{cc|cc} 1 & 2 & 0 & 0 \\ 2 & 0 & 0 & 0 \\ \hline 6 & 3 & 1 & 0 \\ 0 & -2 & 0 & 1 \end{array} \right) = \left( \begin{array}{c|c} D & O \\ \hline F & I \end{array} \right)$

则

$$\begin{aligned} AB &= \begin{pmatrix} I & C \\ O & -I \end{pmatrix} \begin{pmatrix} D & O \\ F & I \end{pmatrix} = \begin{pmatrix} ID + CF & IO + CI \\ OD + (-I)F & OO + (-I)I \end{pmatrix} \\ &= \begin{pmatrix} D + CF & C \\ -F & -I \end{pmatrix} = \left( \begin{array}{cc|cc} & & 1 & 3 \\ & & 2 & 4 \\ \hline -6 & -3 & -1 & 0 \\ 0 & 2 & 0 & -1 \end{array} \right) \end{aligned}$$

其中

$$D + CF = \begin{pmatrix} 1 & 2 \\ 2 & 0 \end{pmatrix} + \begin{pmatrix} 1 & 3 \\ 2 & 4 \end{pmatrix} \begin{pmatrix} 6 & 3 \\ 0 & -2 \end{pmatrix} =$$



## 分块矩阵的运算：乘积

例 设  $A = \left( \begin{array}{cc|cc} 1 & 0 & 1 & 3 \\ 0 & 1 & 2 & 4 \\ \hline 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{array} \right) = \left( \begin{array}{c|c} I & C \\ \hline O & -I \end{array} \right), \quad B = \left( \begin{array}{cc|cc} 1 & 2 & 0 & 0 \\ 2 & 0 & 0 & 0 \\ \hline 6 & 3 & 1 & 0 \\ 0 & -2 & 0 & 1 \end{array} \right) = \left( \begin{array}{c|c} D & O \\ \hline F & I \end{array} \right)$

则

$$\begin{aligned} AB &= \begin{pmatrix} I & C \\ O & -I \end{pmatrix} \begin{pmatrix} D & O \\ F & I \end{pmatrix} = \begin{pmatrix} ID + CF & IO + CI \\ OD + (-I)F & OO + (-I)I \end{pmatrix} \\ &= \begin{pmatrix} D + CF & C \\ -F & -I \end{pmatrix} = \left( \begin{array}{cc|cc} & & 1 & 3 \\ & & 2 & 4 \\ \hline -6 & -3 & -1 & 0 \\ 0 & 2 & 0 & -1 \end{array} \right) \end{aligned}$$

其中

$$D + CF = \begin{pmatrix} 1 & 2 \\ 2 & 0 \end{pmatrix} + \begin{pmatrix} 1 & 3 \\ 2 & 4 \end{pmatrix} \begin{pmatrix} 6 & 3 \\ 0 & -2 \end{pmatrix} = \begin{pmatrix} 6 & -3 \\ 12 & -2 \end{pmatrix}$$

## 分块矩阵的运算：乘积

例 设  $A = \left( \begin{array}{cc|cc} 1 & 0 & 1 & 3 \\ 0 & 1 & 2 & 4 \\ \hline 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{array} \right) = \left( \begin{array}{c|c} I & C \\ \hline O & -I \end{array} \right), B = \left( \begin{array}{cc|cc} 1 & 2 & 0 & 0 \\ 2 & 0 & 0 & 0 \\ \hline 6 & 3 & 1 & 0 \\ 0 & -2 & 0 & 1 \end{array} \right) = \left( \begin{array}{c|c} D & O \\ \hline F & I \end{array} \right)$

则

$$\begin{aligned} AB &= \begin{pmatrix} I & C \\ O & -I \end{pmatrix} \begin{pmatrix} D & O \\ F & I \end{pmatrix} = \begin{pmatrix} ID + CF & IO + CI \\ OD + (-I)F & OO + (-I)I \end{pmatrix} \\ &= \begin{pmatrix} D + CF & C \\ -F & -I \end{pmatrix} = \left( \begin{array}{cc|cc} & & 1 & 3 \\ & & 2 & 4 \\ \hline -6 & -3 & -1 & 0 \\ 0 & 2 & 0 & -1 \end{array} \right) \end{aligned}$$

其中

$$D + CF = \begin{pmatrix} 1 & 2 \\ 2 & 0 \end{pmatrix} + \begin{pmatrix} 1 & 3 \\ 2 & 4 \end{pmatrix} \begin{pmatrix} 6 & 3 \\ 0 & -2 \end{pmatrix} = \begin{pmatrix} 1 & 2 \\ 2 & 0 \end{pmatrix} + \begin{pmatrix} 6 & -3 \\ 12 & -2 \end{pmatrix}$$

## 分块矩阵的运算：乘积

例 设  $A = \left( \begin{array}{cc|cc} 1 & 0 & 1 & 3 \\ 0 & 1 & 2 & 4 \\ \hline 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{array} \right) = \left( \begin{array}{c|c} I & C \\ \hline O & -I \end{array} \right), B = \left( \begin{array}{cc|cc} 1 & 2 & 0 & 0 \\ 2 & 0 & 0 & 0 \\ \hline 6 & 3 & 1 & 0 \\ 0 & -2 & 0 & 1 \end{array} \right) = \left( \begin{array}{c|c} D & O \\ \hline F & I \end{array} \right)$

则

$$\begin{aligned} AB &= \begin{pmatrix} I & C \\ O & -I \end{pmatrix} \begin{pmatrix} D & O \\ F & I \end{pmatrix} = \begin{pmatrix} ID + CF & IO + CI \\ OD + (-I)F & OO + (-I)I \end{pmatrix} \\ &= \begin{pmatrix} D + CF & C \\ -F & -I \end{pmatrix} = \left( \begin{array}{cc|cc} & & 1 & 3 \\ & & 2 & 4 \\ \hline -6 & -3 & -1 & 0 \\ 0 & 2 & 0 & -1 \end{array} \right) \end{aligned}$$

其中

$$D + CF = \begin{pmatrix} 1 & 2 \\ 2 & 0 \end{pmatrix} + \begin{pmatrix} 1 & 3 \\ 2 & 4 \end{pmatrix} \begin{pmatrix} 6 & 3 \\ 0 & -2 \end{pmatrix} = \begin{pmatrix} 1 & 2 \\ 2 & 0 \end{pmatrix} + \begin{pmatrix} 6 & -3 \\ 12 & -2 \end{pmatrix} = \begin{pmatrix} 7 & -1 \\ 14 & -2 \end{pmatrix}$$

## 分块矩阵的运算：乘积

例 设  $A = \left( \begin{array}{cc|cc} 1 & 0 & 1 & 3 \\ 0 & 1 & 2 & 4 \\ \hline 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{array} \right) = \left( \begin{array}{c|c} I & C \\ \hline O & -I \end{array} \right), B = \left( \begin{array}{cc|cc} 1 & 2 & 0 & 0 \\ 2 & 0 & 0 & 0 \\ \hline 6 & 3 & 1 & 0 \\ 0 & -2 & 0 & 1 \end{array} \right) = \left( \begin{array}{c|c} D & O \\ \hline F & I \end{array} \right)$

则

$$\begin{aligned} AB &= \begin{pmatrix} I & C \\ O & -I \end{pmatrix} \begin{pmatrix} D & O \\ F & I \end{pmatrix} = \begin{pmatrix} ID + CF & IO + CI \\ OD + (-I)F & OO + (-I)I \end{pmatrix} \\ &= \begin{pmatrix} D + CF & C \\ -F & -I \end{pmatrix} = \left( \begin{array}{cc|cc} 7 & -1 & 1 & 3 \\ 14 & -2 & 2 & 4 \\ \hline -6 & -3 & -1 & 0 \\ 0 & 2 & 0 & -1 \end{array} \right) \end{aligned}$$

其中

$$D + CF = \begin{pmatrix} 1 & 2 \\ 2 & 0 \end{pmatrix} + \begin{pmatrix} 1 & 3 \\ 2 & 4 \end{pmatrix} \begin{pmatrix} 6 & 3 \\ 0 & -2 \end{pmatrix} = \begin{pmatrix} 1 & 2 \\ 2 & 0 \end{pmatrix} + \begin{pmatrix} 6 & -3 \\ 12 & -2 \end{pmatrix} = \begin{pmatrix} 7 & -1 \\ 14 & -2 \end{pmatrix}$$

## 分块矩阵的运算：乘积

例 设  $A = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 1 & 3 & 2 & 0 \\ 5 & 2 & 0 & 2 \end{pmatrix}$

,  $B = \begin{pmatrix} -1 & 0 & 2 & 1 \\ 0 & -1 & 3 & 4 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$

则

$$AB =$$

## 分块矩阵的运算：乘积

例 设  $A = \left( \begin{array}{cc|cc} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ \hline 1 & 3 & 2 & 0 \\ 5 & 2 & 0 & 2 \end{array} \right) = \left( \begin{array}{c|c} I & O \\ \hline A_1 & 2I \end{array} \right), \quad B = \begin{pmatrix} -1 & 0 & 2 & 1 \\ 0 & -1 & 3 & 4 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$

则

$$AB =$$

## 分块矩阵的运算：乘积

例 设  $A = \left( \begin{array}{cc|cc} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ \hline 1 & 3 & 2 & 0 \\ 5 & 2 & 0 & 2 \end{array} \right) = \left( \begin{array}{c|c} I & O \\ \hline A_1 & 2I \end{array} \right), \quad B = \left( \begin{array}{cc|cc} -1 & 0 & 2 & 1 \\ 0 & -1 & 3 & 4 \\ \hline 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{array} \right) = \left( \begin{array}{c|c} -I & B_1 \\ \hline O & I \end{array} \right)$  则

$$AB =$$

## 分块矩阵的运算：乘积

例 设  $A = \left( \begin{array}{cc|cc} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ \hline 1 & 3 & 2 & 0 \\ 5 & 2 & 0 & 2 \end{array} \right) = \left( \begin{array}{c|c} I & O \\ \hline A_1 & 2I \end{array} \right), \quad B = \left( \begin{array}{cc|cc} -1 & 0 & 2 & 1 \\ 0 & -1 & 3 & 4 \\ \hline 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{array} \right) = \left( \begin{array}{c|c} -I & B_1 \\ \hline O & I \end{array} \right)$  则

$$AB = \left( \begin{array}{c|c} I & O \\ \hline A_1 & 2I \end{array} \right) \left( \begin{array}{c|c} -I & B_1 \\ \hline O & I \end{array} \right) =$$



## 分块矩阵的运算：乘积

例 设  $A = \left( \begin{array}{cc|cc} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ \hline 1 & 3 & 2 & 0 \\ 5 & 2 & 0 & 2 \end{array} \right) = \left( \begin{array}{c|c} I & O \\ \hline A_1 & 2I \end{array} \right)$ ,  $B = \left( \begin{array}{cc|cc} -1 & 0 & 2 & 1 \\ 0 & -1 & 3 & 4 \\ \hline 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{array} \right) = \left( \begin{array}{c|c} -I & B_1 \\ \hline O & I \end{array} \right)$  则

$$AB = \left( \begin{array}{c|c} I & O \\ \hline A_1 & 2I \end{array} \right) \left( \begin{array}{c|c} -I & B_1 \\ \hline O & I \end{array} \right) = \left( \begin{array}{c|c} & \\ \hline & \end{array} \right)$$

## 分块矩阵的运算：乘积

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$$AB = \left( \begin{array}{c|c} I & O \\ \hline A_1 & 2I \end{array} \right) \left( \begin{array}{c|c} -I & B_1 \\ \hline O & I \end{array} \right) = \left( \begin{array}{c|c} I(-I) + OO & IB_1 + 2II \\ \hline A_1(-I) + 2IO & A_1B_1 + 2II \end{array} \right)$$

## 分块矩阵的运算：乘积

例 设  $A = \left( \begin{array}{cc|cc} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ \hline 1 & 3 & 2 & 0 \\ 5 & 2 & 0 & 2 \end{array} \right) = \left( \begin{array}{c|c} I & O \\ \hline A_1 & 2I \end{array} \right), \quad B = \left( \begin{array}{cc|cc} -1 & 0 & 2 & 1 \\ 0 & -1 & 3 & 4 \\ \hline 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{array} \right) = \left( \begin{array}{c|c} -I & B_1 \\ \hline O & I \end{array} \right)$  则

$$AB = \left( \begin{array}{c|c} I & O \\ \hline A_1 & 2I \end{array} \right) \left( \begin{array}{c|c} -I & B_1 \\ \hline O & I \end{array} \right) = \left( \begin{array}{cc} I(-I) + OO & IB_1 + OI \end{array} \right)$$

## 分块矩阵的运算：乘积

例 设  $A = \left( \begin{array}{cc|cc} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ \hline 1 & 3 & 2 & 0 \\ 5 & 2 & 0 & 2 \end{array} \right) = \left( \begin{array}{c|c} I & O \\ \hline A_1 & 2I \end{array} \right), \quad B = \left( \begin{array}{cc|cc} -1 & 0 & 2 & 1 \\ 0 & -1 & 3 & 4 \\ \hline 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{array} \right) = \left( \begin{array}{c|c} -I & B_1 \\ \hline O & I \end{array} \right)$  则

$$AB = \left( \begin{array}{c|c} I & O \\ \hline A_1 & 2I \end{array} \right) \left( \begin{array}{c|c} -I & B_1 \\ \hline O & I \end{array} \right) = \left( \begin{array}{cc} I(-I) + OO & IB_1 + OI \\ \hline A_1(-I) + 2IO & \end{array} \right)$$

## 分块矩阵的运算：乘积

例 设  $A = \left( \begin{array}{cc|cc} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ \hline 1 & 3 & 2 & 0 \\ 5 & 2 & 0 & 2 \end{array} \right) = \left( \begin{array}{c|c} I & O \\ \hline A_1 & 2I \end{array} \right), \quad B = \left( \begin{array}{cc|cc} -1 & 0 & 2 & 1 \\ 0 & -1 & 3 & 4 \\ \hline 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{array} \right) = \left( \begin{array}{c|c} -I & B_1 \\ \hline O & I \end{array} \right)$  则

$$AB = \left( \begin{array}{c|c} I & O \\ \hline A_1 & 2I \end{array} \right) \left( \begin{array}{c|c} -I & B_1 \\ \hline O & I \end{array} \right) = \left( \begin{array}{cc} I(-I) + OO & IB_1 + OI \\ A_1(-I) + 2IO & A_1B_1 + 2I \end{array} \right)$$

## 分块矩阵的运算：乘积

例 设  $A = \left( \begin{array}{cc|cc} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ \hline 1 & 3 & 2 & 0 \\ 5 & 2 & 0 & 2 \end{array} \right) = \left( \begin{array}{c|c} I & O \\ \hline A_1 & 2I \end{array} \right)$ ,  $B = \left( \begin{array}{cc|cc} -1 & 0 & 2 & 1 \\ 0 & -1 & 3 & 4 \\ \hline 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{array} \right) = \left( \begin{array}{c|c} -I & B_1 \\ \hline O & I \end{array} \right)$  则

$$AB = \left( \begin{array}{c|c} I & O \\ \hline A_1 & 2I \end{array} \right) \left( \begin{array}{c|c} -I & B_1 \\ \hline O & I \end{array} \right) = \left( \begin{array}{cc} I(-I) + OO & IB_1 + OI \\ A_1(-I) + 2IO & A_1B_1 + 2I \end{array} \right)$$

$$= \left( \begin{array}{cc} & \\ & \end{array} \right) =$$

## 分块矩阵的运算：乘积

例 设  $A = \left( \begin{array}{cc|cc} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ \hline 1 & 3 & 2 & 0 \\ 5 & 2 & 0 & 2 \end{array} \right) = \left( \begin{array}{c|c} I & O \\ \hline A_1 & 2I \end{array} \right)$ ,  $B = \left( \begin{array}{cc|cc} -1 & 0 & 2 & 1 \\ 0 & -1 & 3 & 4 \\ \hline 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{array} \right) = \left( \begin{array}{c|c} -I & B_1 \\ \hline O & I \end{array} \right)$  则

$$AB = \left( \begin{array}{c|c} I & O \\ \hline A_1 & 2I \end{array} \right) \left( \begin{array}{c|c} -I & B_1 \\ \hline O & I \end{array} \right) = \left( \begin{array}{cc} I(-I) + OO & IB_1 + OI \\ \hline A_1(-I) + 2IO & A_1B_1 + 2I \end{array} \right)$$

$$= \left( \begin{array}{cc} -I & B_1 \\ \hline A_1(-I) + 2IO & A_1B_1 + 2I \end{array} \right) =$$

## 分块矩阵的运算：乘积

例 设  $A = \left( \begin{array}{cc|cc} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ \hline 1 & 3 & 2 & 0 \\ 5 & 2 & 0 & 2 \end{array} \right) = \left( \begin{array}{c|c} I & O \\ \hline A_1 & 2I \end{array} \right)$ ,  $B = \left( \begin{array}{cc|cc} -1 & 0 & 2 & 1 \\ 0 & -1 & 3 & 4 \\ \hline 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{array} \right) = \left( \begin{array}{c|c} -I & B_1 \\ \hline O & I \end{array} \right)$  则

$$\begin{aligned} AB &= \left( \begin{array}{c|c} I & O \\ \hline A_1 & 2I \end{array} \right) \left( \begin{array}{c|c} -I & B_1 \\ \hline O & I \end{array} \right) = \left( \begin{array}{cc} I(-I) + OO & IB_1 + OI \\ \hline A_1(-I) + 2IO & A_1B_1 + 2I \end{array} \right) \\ &= \left( \begin{array}{cc} -I & B_1 \\ \hline & \end{array} \right) = \end{aligned}$$



## 分块矩阵的运算：乘积

例 设  $A = \left( \begin{array}{cc|cc} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ \hline 1 & 3 & 2 & 0 \\ 5 & 2 & 0 & 2 \end{array} \right) = \left( \begin{array}{c|c} I & O \\ \hline A_1 & 2I \end{array} \right)$ ,  $B = \left( \begin{array}{cc|cc} -1 & 0 & 2 & 1 \\ 0 & -1 & 3 & 4 \\ \hline 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{array} \right) = \left( \begin{array}{c|c} -I & B_1 \\ \hline O & I \end{array} \right)$  则

$$AB = \left( \begin{array}{c|c} I & O \\ \hline A_1 & 2I \end{array} \right) \left( \begin{array}{c|c} -I & B_1 \\ \hline O & I \end{array} \right) = \left( \begin{array}{cc} I(-I) + OO & IB_1 + OI \\ A_1(-I) + 2IO & A_1B_1 + 2I \end{array} \right)$$

$$= \left( \begin{array}{cc} -I & B_1 \\ -A_1 & \end{array} \right) =$$

## 分块矩阵的运算：乘积

例 设  $A = \left( \begin{array}{cc|cc} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ \hline 1 & 3 & 2 & 0 \\ 5 & 2 & 0 & 2 \end{array} \right) = \left( \begin{array}{c|c} I & O \\ \hline A_1 & 2I \end{array} \right), \quad B = \left( \begin{array}{cc|cc} -1 & 0 & 2 & 1 \\ 0 & -1 & 3 & 4 \\ \hline 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{array} \right) = \left( \begin{array}{c|c} -I & B_1 \\ \hline O & I \end{array} \right)$  则

$$AB = \left( \begin{array}{c|c} I & O \\ \hline A_1 & 2I \end{array} \right) \left( \begin{array}{c|c} -I & B_1 \\ \hline O & I \end{array} \right) = \left( \begin{array}{cc} I(-I) + OO & IB_1 + OI \\ A_1(-I) + 2IO & A_1B_1 + 2I \end{array} \right)$$

$$= \left( \begin{array}{cc} -I & B_1 \\ -A_1 & A_1B_1 + 2I \end{array} \right) =$$

## 分块矩阵的运算：乘积

例 设  $A = \left( \begin{array}{cc|cc} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ \hline 1 & 3 & 2 & 0 \\ 5 & 2 & 0 & 2 \end{array} \right) = \left( \begin{array}{c|c} I & O \\ \hline A_1 & 2I \end{array} \right)$ ,  $B = \left( \begin{array}{cc|cc} -1 & 0 & 2 & 1 \\ 0 & -1 & 3 & 4 \\ \hline 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{array} \right) = \left( \begin{array}{c|c} -I & B_1 \\ \hline O & I \end{array} \right)$  则

$$\begin{aligned} AB &= \left( \begin{array}{c|c} I & O \\ \hline A_1 & 2I \end{array} \right) \left( \begin{array}{c|c} -I & B_1 \\ \hline O & I \end{array} \right) = \left( \begin{array}{cc} I(-I) + OO & IB_1 + OI \\ A_1(-I) + 2IO & A_1B_1 + 2I \end{array} \right) \\ &= \left( \begin{array}{cc} -I & B_1 \\ -A_1 & A_1B_1 + 2I \end{array} \right) = \left( \begin{array}{c|c} \vdots & \vdots \\ \hline \vdots & \vdots \end{array} \right) \end{aligned}$$

## 分块矩阵的运算：乘积

例 设  $A = \left( \begin{array}{cc|cc} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ \hline 1 & 3 & 2 & 0 \\ 5 & 2 & 0 & 2 \end{array} \right) = \left( \begin{array}{c|c} I & O \\ \hline A_1 & 2I \end{array} \right)$ ,  $B = \left( \begin{array}{cc|cc} -1 & 0 & 2 & 1 \\ 0 & -1 & 3 & 4 \\ \hline 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{array} \right) = \left( \begin{array}{c|c} -I & B_1 \\ \hline O & I \end{array} \right)$  则

$$\begin{aligned} AB &= \left( \begin{array}{c|c} I & O \\ \hline A_1 & 2I \end{array} \right) \left( \begin{array}{c|c} -I & B_1 \\ \hline O & I \end{array} \right) = \left( \begin{array}{cc} I(-I) + OO & IB_1 + OI \\ \hline A_1(-I) + 2IO & A_1B_1 + 2II \end{array} \right) \\ &= \left( \begin{array}{cc} -I & B_1 \\ \hline -A_1 & A_1B_1 + 2I \end{array} \right) = \left( \begin{array}{cc|cc} -1 & 0 & & \\ 0 & -1 & & \\ \hline & & & \\ & & & \end{array} \right) \end{aligned}$$

## 分块矩阵的运算：乘积

例 设  $A = \left( \begin{array}{cc|cc} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ \hline 1 & 3 & 2 & 0 \\ 5 & 2 & 0 & 2 \end{array} \right) = \left( \begin{array}{c|c} I & O \\ \hline A_1 & 2I \end{array} \right)$ ,  $B = \left( \begin{array}{cc|cc} -1 & 0 & 2 & 1 \\ 0 & -1 & 3 & 4 \\ \hline 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{array} \right) = \left( \begin{array}{c|c} -I & B_1 \\ \hline O & I \end{array} \right)$  则

$$\begin{aligned} AB &= \left( \begin{array}{c|c} I & O \\ \hline A_1 & 2I \end{array} \right) \left( \begin{array}{c|c} -I & B_1 \\ \hline O & I \end{array} \right) = \left( \begin{array}{cc|cc} I(-I) + OO & IB_1 + OI \\ \hline A_1(-I) + 2IO & A_1B_1 + 2I \end{array} \right) \\ &= \left( \begin{array}{cc|cc} -I & B_1 \\ \hline -A_1 & A_1B_1 + 2I \end{array} \right) = \left( \begin{array}{cc|cc} -1 & 0 & 2 & 1 \\ 0 & -1 & 3 & 4 \\ \hline & & & \\ & & & \end{array} \right) \end{aligned}$$

## 分块矩阵的运算：乘积

例 设  $A = \left( \begin{array}{cc|cc} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ \hline 1 & 3 & 2 & 0 \\ 5 & 2 & 0 & 2 \end{array} \right) = \left( \begin{array}{c|c} I & O \\ \hline A_1 & 2I \end{array} \right)$ ,  $B = \left( \begin{array}{cc|cc} -1 & 0 & 2 & 1 \\ 0 & -1 & 3 & 4 \\ \hline 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{array} \right) = \left( \begin{array}{c|c} -I & B_1 \\ \hline O & I \end{array} \right)$  则

$$\begin{aligned} AB &= \left( \begin{array}{c|c} I & O \\ \hline A_1 & 2I \end{array} \right) \left( \begin{array}{c|c} -I & B_1 \\ \hline O & I \end{array} \right) = \left( \begin{array}{cc|cc} I(-I) + OO & IB_1 + OI \\ \hline A_1(-I) + 2IO & A_1B_1 + 2I \end{array} \right) \\ &= \left( \begin{array}{cc|cc} -I & B_1 \\ \hline -A_1 & A_1B_1 + 2I \end{array} \right) = \left( \begin{array}{cc|cc} -1 & 0 & 2 & 1 \\ 0 & -1 & 3 & 4 \\ \hline -1 & -3 & - & - \\ -5 & -2 & - & - \end{array} \right) \end{aligned}$$

## 分块矩阵的运算：乘积

例 设  $A = \left( \begin{array}{cc|cc} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ \hline 1 & 3 & 2 & 0 \\ 5 & 2 & 0 & 2 \end{array} \right) = \left( \begin{array}{c|c} I & O \\ \hline A_1 & 2I \end{array} \right)$ ,  $B = \left( \begin{array}{cc|cc} -1 & 0 & 2 & 1 \\ 0 & -1 & 3 & 4 \\ \hline 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{array} \right) = \left( \begin{array}{c|c} -I & B_1 \\ \hline O & I \end{array} \right)$  则

$$\begin{aligned} AB &= \left( \begin{array}{c|c} I & O \\ \hline A_1 & 2I \end{array} \right) \left( \begin{array}{c|c} -I & B_1 \\ \hline O & I \end{array} \right) = \left( \begin{array}{cc|cc} I(-I) + OO & IB_1 + OI \\ \hline A_1(-I) + 2IO & A_1B_1 + 2I \end{array} \right) \\ &= \left( \begin{array}{cc|cc} -I & B_1 \\ \hline -A_1 & A_1B_1 + 2I \end{array} \right) = \left( \begin{array}{cc|cc} -1 & 0 & 2 & 1 \\ 0 & -1 & 3 & 4 \\ \hline -1 & -3 & - & - \\ -5 & -2 & - & - \end{array} \right) \end{aligned}$$

其中

$$A_1B_1 + 2I =$$

## 分块矩阵的运算：乘积

例 设  $A = \left( \begin{array}{cc|cc} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ \hline 1 & 3 & 2 & 0 \\ 5 & 2 & 0 & 2 \end{array} \right) = \left( \begin{array}{c|c} I & O \\ \hline A_1 & 2I \end{array} \right)$ ,  $B = \left( \begin{array}{cc|cc} -1 & 0 & 2 & 1 \\ 0 & -1 & 3 & 4 \\ \hline 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{array} \right) = \left( \begin{array}{c|c} -I & B_1 \\ \hline O & I \end{array} \right)$  则

$$\begin{aligned} AB &= \left( \begin{array}{c|c} I & O \\ \hline A_1 & 2I \end{array} \right) \left( \begin{array}{c|c} -I & B_1 \\ \hline O & I \end{array} \right) = \left( \begin{array}{cc} I(-I) + OO & IB_1 + OI \\ \hline A_1(-I) + 2IO & A_1B_1 + 2I \end{array} \right) \\ &= \left( \begin{array}{cc} -I & B_1 \\ \hline -A_1 & A_1B_1 + 2I \end{array} \right) = \left( \begin{array}{cc|cc} -1 & 0 & 2 & 1 \\ 0 & -1 & 3 & 4 \\ \hline -1 & -3 & - & - \\ -5 & -2 & - & - \end{array} \right) \end{aligned}$$

其中

$$A_1B_1 + 2I = \begin{pmatrix} 1 & 3 \\ 5 & 2 \end{pmatrix} \begin{pmatrix} 2 & 1 \\ 3 & 4 \end{pmatrix} + 2 \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} =$$



## 分块矩阵的运算：乘积

例 设  $A = \left( \begin{array}{cc|cc} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ \hline 1 & 3 & 2 & 0 \\ 5 & 2 & 0 & 2 \end{array} \right) = \left( \begin{array}{c|c} I & O \\ \hline A_1 & 2I \end{array} \right)$ ,  $B = \left( \begin{array}{cc|cc} -1 & 0 & 2 & 1 \\ 0 & -1 & 3 & 4 \\ \hline 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{array} \right) = \left( \begin{array}{c|c} -I & B_1 \\ \hline O & I \end{array} \right)$  则

$$\begin{aligned} AB &= \left( \begin{array}{c|c} I & O \\ \hline A_1 & 2I \end{array} \right) \left( \begin{array}{c|c} -I & B_1 \\ \hline O & I \end{array} \right) = \left( \begin{array}{cc|cc} I(-I) + OO & IB_1 + OI \\ \hline A_1(-I) + 2IO & A_1B_1 + 2I \end{array} \right) \\ &= \left( \begin{array}{cc|cc} -I & B_1 \\ \hline -A_1 & A_1B_1 + 2I \end{array} \right) = \left( \begin{array}{cc|cc} -1 & 0 & 2 & 1 \\ 0 & -1 & 3 & 4 \\ \hline -1 & -3 & - & - \\ -5 & -2 & - & - \end{array} \right) \end{aligned}$$

其中

$$A_1B_1 + 2I = \begin{pmatrix} 1 & 3 \\ 5 & 2 \end{pmatrix} \begin{pmatrix} 2 & 1 \\ 3 & 4 \end{pmatrix} + 2 \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} = \begin{pmatrix} 11 & 13 \\ 16 & 13 \end{pmatrix} +$$

## 分块矩阵的运算：乘积

例 设  $A = \left( \begin{array}{cc|cc} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ \hline 1 & 3 & 2 & 0 \\ 5 & 2 & 0 & 2 \end{array} \right) = \left( \begin{array}{c|c} I & O \\ \hline A_1 & 2I \end{array} \right)$ ,  $B = \left( \begin{array}{cc|cc} -1 & 0 & 2 & 1 \\ 0 & -1 & 3 & 4 \\ \hline 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{array} \right) = \left( \begin{array}{c|c} -I & B_1 \\ \hline O & I \end{array} \right)$  则

$$\begin{aligned} AB &= \left( \begin{array}{c|c} I & O \\ \hline A_1 & 2I \end{array} \right) \left( \begin{array}{c|c} -I & B_1 \\ \hline O & I \end{array} \right) = \left( \begin{array}{cc} I(-I) + OO & IB_1 + OI \\ \hline A_1(-I) + 2IO & A_1B_1 + 2I \end{array} \right) \\ &= \left( \begin{array}{cc} -I & B_1 \\ \hline -A_1 & A_1B_1 + 2I \end{array} \right) = \left( \begin{array}{cc|cc} -1 & 0 & 2 & 1 \\ 0 & -1 & 3 & 4 \\ \hline -1 & -3 & - & - \\ -5 & -2 & - & - \end{array} \right) \end{aligned}$$

其中

$$A_1B_1 + 2I = \begin{pmatrix} 1 & 3 \\ 5 & 2 \end{pmatrix} \begin{pmatrix} 2 & 1 \\ 3 & 4 \end{pmatrix} + 2 \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} = \begin{pmatrix} 11 & 13 \\ 16 & 13 \end{pmatrix} + \begin{pmatrix} 2 & 0 \\ 0 & 2 \end{pmatrix}$$

## 分块矩阵的运算：乘积

例 设  $A = \left( \begin{array}{cc|cc} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ \hline 1 & 3 & 2 & 0 \\ 5 & 2 & 0 & 2 \end{array} \right) = \left( \begin{array}{c|c} I & O \\ \hline A_1 & 2I \end{array} \right)$ ,  $B = \left( \begin{array}{cc|cc} -1 & 0 & 2 & 1 \\ 0 & -1 & 3 & 4 \\ \hline 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{array} \right) = \left( \begin{array}{c|c} -I & B_1 \\ \hline O & I \end{array} \right)$  则

$$\begin{aligned} AB &= \left( \begin{array}{c|c} I & O \\ \hline A_1 & 2I \end{array} \right) \left( \begin{array}{c|c} -I & B_1 \\ \hline O & I \end{array} \right) = \left( \begin{array}{cc} I(-I) + OO & IB_1 + OI \\ \hline A_1(-I) + 2IO & A_1B_1 + 2I \end{array} \right) \\ &= \left( \begin{array}{cc} -I & B_1 \\ \hline -A_1 & A_1B_1 + 2I \end{array} \right) = \left( \begin{array}{cc|cc} -1 & 0 & 2 & 1 \\ 0 & -1 & 3 & 4 \\ \hline -1 & -3 & - & - \\ -5 & -2 & - & - \end{array} \right) \end{aligned}$$

其中

$$A_1B_1 + 2I = \begin{pmatrix} 1 & 3 \\ 5 & 2 \end{pmatrix} \begin{pmatrix} 2 & 1 \\ 3 & 4 \end{pmatrix} + 2 \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} = \begin{pmatrix} 11 & 13 \\ 16 & 13 \end{pmatrix} + \begin{pmatrix} 2 & 0 \\ 0 & 2 \end{pmatrix} = \begin{pmatrix} 13 & 13 \\ 16 & 15 \end{pmatrix}$$

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例 设  $A, B$  均为 2 阶方阵, 且  $|A| = 2, |B| = 3$ , 计算分块矩阵的乘积

$$\begin{pmatrix} O & A \\ B & O \end{pmatrix} \begin{pmatrix} O & B^* \\ A^* & O \end{pmatrix}$$

并计算该乘积的行列式。

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解

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解

$$\begin{pmatrix} O & A \\ B & O \end{pmatrix} \begin{pmatrix} O & B^* \\ A^* & O \end{pmatrix} = \begin{pmatrix} OO + AA^* & \\ & \end{pmatrix}$$

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解

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$$\text{所以 } \left| \begin{pmatrix} O & A \\ B & O \end{pmatrix} \begin{pmatrix} O & B^* \\ A^* & O \end{pmatrix} \right| = \left| \begin{array}{cc|cc} 2 & & & \\ & 2 & & \\ \hline & & 3 & \\ & & & 3 \end{array} \right| =$$

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$$\text{所以 } \left| \begin{pmatrix} O & A \\ B & O \end{pmatrix} \begin{pmatrix} O & B^* \\ A^* & O \end{pmatrix} \right| = \left| \begin{array}{cc|cc} 2 & & & \\ & 2 & & \\ \hline & & 3 & \\ & & & 3 \end{array} \right| = 4 \times 9 =$$

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$$\text{所以 } \left| \begin{pmatrix} O & A \\ B & O \end{pmatrix} \begin{pmatrix} O & B^* \\ A^* & O \end{pmatrix} \right| = \left| \begin{array}{cc|cc} 2 & & & \\ & 2 & & \\ \hline & & 3 & \\ & & & 3 \end{array} \right| = 4 \times 9 = 36$$

# 分块矩阵的运算：乘积

例 设

$$A = \begin{pmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{m1} & a_{m2} & \cdots & a_{mn} \end{pmatrix}, \quad I = \begin{pmatrix} 1 & 0 & \cdots & 0 \\ 0 & 1 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & 1 \end{pmatrix}$$



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则

$$AI$$

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$$AI = A(\varepsilon_1 \ \varepsilon_2 \ \cdots \ \varepsilon_n) =$$

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则

$$AI = A(\varepsilon_1 \quad \varepsilon_2 \quad \cdots \quad \varepsilon_n) = (A\varepsilon_1 \quad A\varepsilon_2 \quad \cdots \quad A\varepsilon_n)$$

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例 设

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则

$$AI = A(\varepsilon_1 \ \varepsilon_2 \ \cdots \ \varepsilon_n) = (A\varepsilon_1 \ A\varepsilon_2 \ \cdots \ A\varepsilon_n)$$

$$= \begin{pmatrix} \vdots & \vdots & \vdots \\ \vdots & \vdots & \vdots \\ \vdots & \vdots & \vdots \end{pmatrix}$$

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则

$$AI = A(\varepsilon_1 \ \varepsilon_2 \ \cdots \ \varepsilon_n) = (A\varepsilon_1 \ A\varepsilon_2 \ \cdots \ A\varepsilon_n)$$

$$= \begin{pmatrix} a_{11} & \vdots & \vdots & \vdots \\ a_{21} & \vdots & \vdots & \vdots \\ \vdots & \vdots & \vdots & \vdots \\ a_{m1} & \vdots & \vdots & \vdots \end{pmatrix}$$

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则

$$AI = A(\varepsilon_1 \ \varepsilon_2 \ \cdots \ \varepsilon_n) = (A\varepsilon_1 \ A\varepsilon_2 \ \cdots \ A\varepsilon_n)$$

$$= \begin{pmatrix} a_{11} & a_{12} & \vdots & \vdots \\ a_{21} & a_{22} & \vdots & \vdots \\ \vdots & \vdots & \ddots & \vdots \\ a_{m1} & a_{m2} & \vdots & \vdots \end{pmatrix}$$



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## 分块矩阵的运算：乘积

例 设

$$A = \begin{pmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{m1} & a_{m2} & \cdots & a_{mn} \end{pmatrix}, \quad I = \begin{pmatrix} 1 & 0 & \cdots & 0 \\ 0 & 1 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & 1 \end{pmatrix} = (\varepsilon_1 \ \varepsilon_2 \ \cdots \ \varepsilon_n)$$

则

$$\begin{aligned} AI &= A(\varepsilon_1 \ \varepsilon_2 \ \cdots \ \varepsilon_n) = (A\varepsilon_1 \ A\varepsilon_2 \ \cdots \ A\varepsilon_n) \\ &= \begin{pmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{1n} \\ \vdots & \vdots & \ddots & a_{1n} \\ a_{m1} & a_{m2} & \cdots & a_{1n} \end{pmatrix} = (A_1 \ A_2 \ \cdots \ A_n) \end{aligned}$$

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