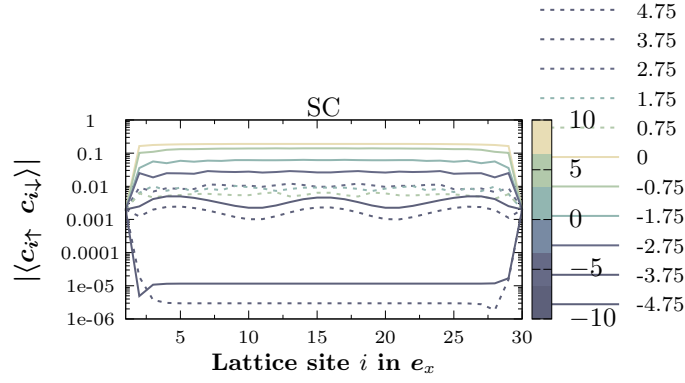


# 1 Benchmark on SC30

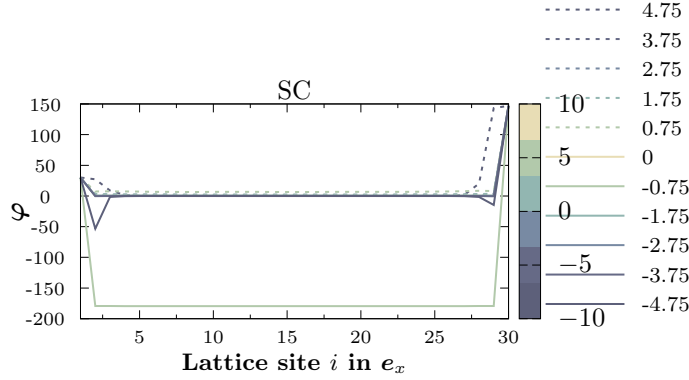
## 1.1 Length and argument for different $\mu$

### 1.1.1 Fixed $\Delta$ on both sides

Zero Phase ..



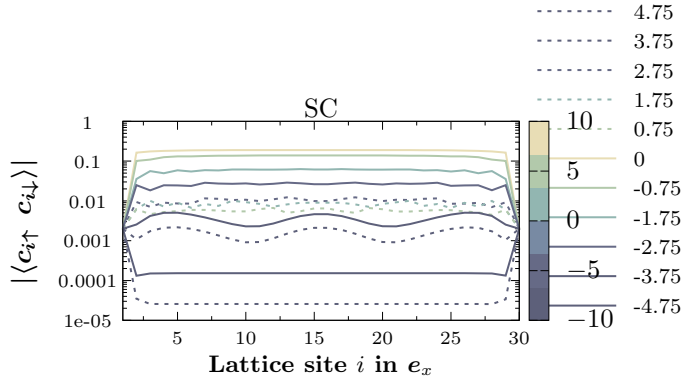
(a) Meanline. Surrouned with vaccuum for different mu. Zero Phase  $\varphi = 117$  deg



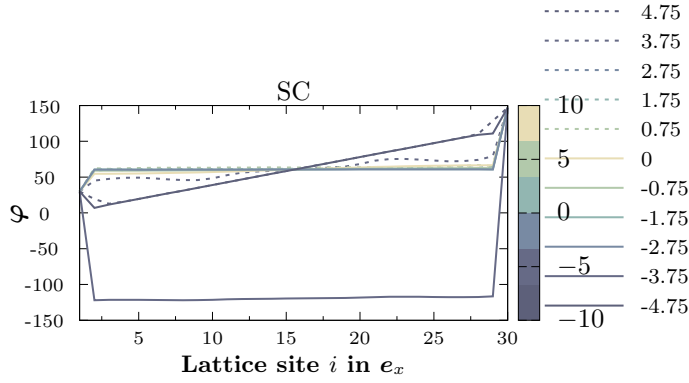
(b) Meanline of the phase. Surrouned with vaccuum for different mu. Zero Phase  $\varphi = 117$  deg

**Figure 1:** Using a model where the phase is set to **zero** erverywhere but right and left side on the start.

Linear Gradient ..



(a) Meanline. Surrounded with vacuum for different  $\mu$ . Phase Gradient  $\varphi = 117$  deg



(b) Meanline of the phase. Surrounded with vacuum for different  $\mu$ . Phase Gradient  $\varphi = 117$  deg

**Figure 2:** Using a model where the phase is set to be a **gradient from left to the right side** on the start.

The ability of the system to form Cooper pairs is higher when the chemical potential approaches zero and reach a minimum when  $|\mu|$  get far from zero. According to <https://abhirup-m.github.io/assets/pdfs/tbm.pdf> when  $\mu$  is positive, we fill up the band. We are going to stay with a filled band. This  $|\mu|$ -dependence can be understood as follows. When the band is not filled  $\mu < -4$  we have no electron to fill Cooper pairs. When  $\mu > 4$  there is no degree of freedom left for the electrons to move around (metal becomes an insulator) and we can't form Cooper pairs.

What we also see is that at the same  $|\mu|$ , the negative  $\mu$  gives significantly more Cooper pairs than the positive one. A reason for it could be that the Fermi surface is smaller in the first case than the second one.

As we are going to see the  $\mu = -3.75$  is not converging. The results alternate between its positive and negative value in the real part. This means the phase drop we have isn't really a result, depending on when we stop, we get  $-120$  or  $-120 + 180 = 60$  which lies among the other curves.

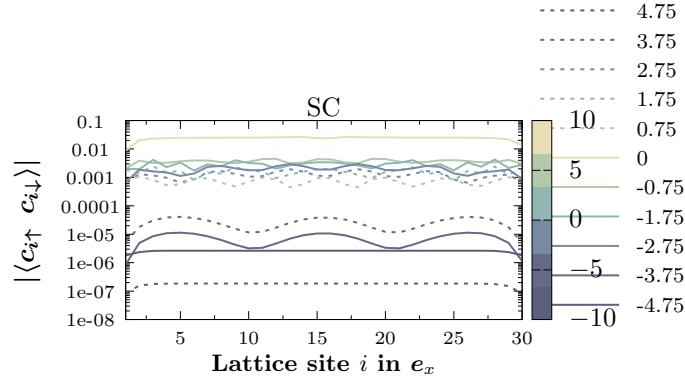
We have  $\pi/6$  on the left, then 0 then  $\pi/6 + 117$  on the right. In the Zero phase, we have a drop to zero and then a jump to  $\pi/6 + 117$ .

Here we setup a linear gradient from  $\pi/6$  to  $\pi/6 + 117$ . The phase has a plateau in the middle

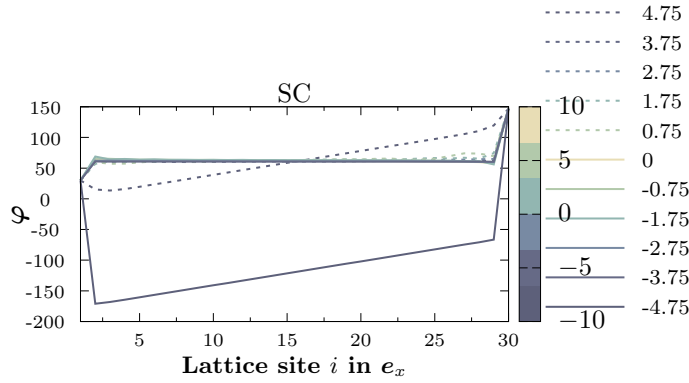
and then jumps at the end. The heigher the  $|\mu|$ , the more the gradient is observable.

### 1.1.2 Fixed phase on both sides

Linear Gradient ..



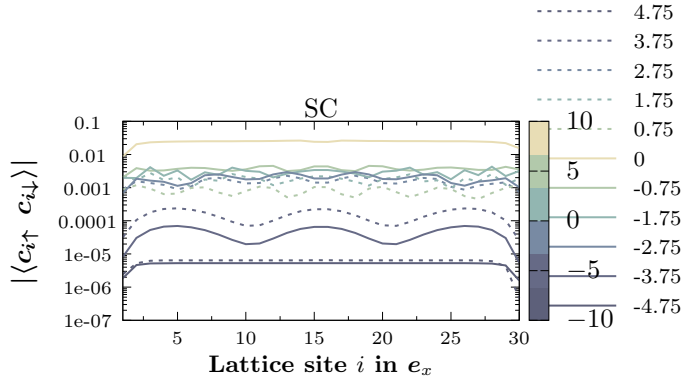
(a) All mean line. Surrounded with vacuum. LinearGradient Phase  $\varphi = 117$  deg.



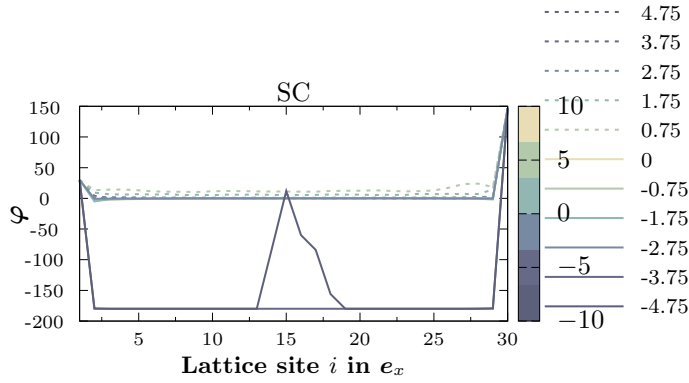
(b) Phase mean line. Surrounded with vacuum. LinearGradient Phase  $\varphi = 117$  deg.

**Figure 3:** Using a model where the phase is set to be a gradient from left to the right side on the start.

Zero Phase ..



(a) All mean line. Surrounded with vacuum. ZeroPhase Phase  $\varphi = 117$  deg.



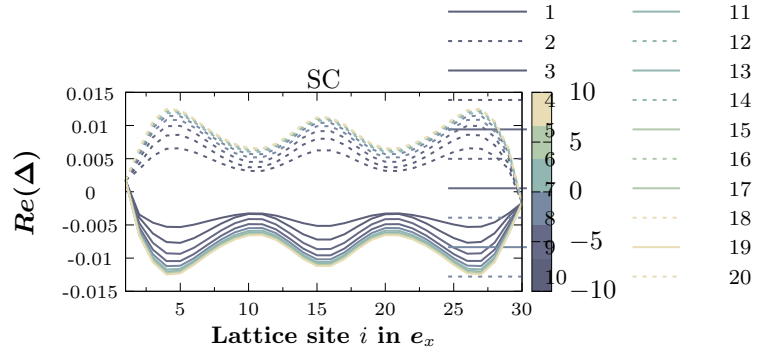
(b) Phase mean line. Surrounded with vacuum. ZeroPhase Phase  $\varphi = 117$  deg.

**Figure 4:** Using a model where the phase is set to **zero** everywhere but **right and left** side on the start.

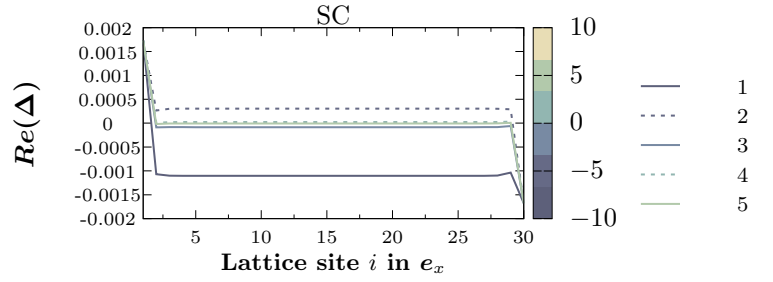
## 1.2 Convergence of the meanline

This section shows how the meanline converges for different  $\mu$  and different phase setup. The key point is to see that  $\mu = -3.75$  doesn't and then oscillates around the same value. The more step, the closer the absolute value of the oscillation will be to end one. We also see the influence of the phase gradient and the zero phase.

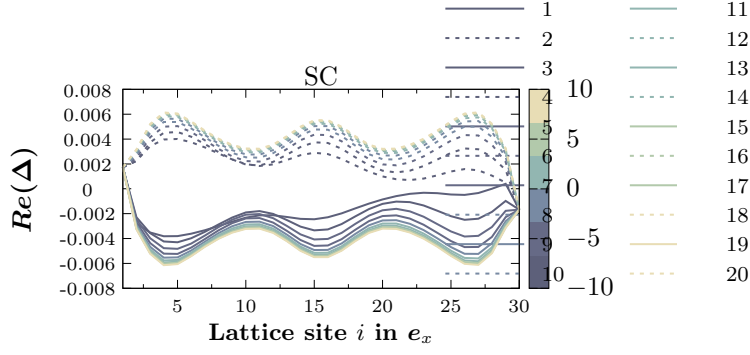
**Zero Phase** ..



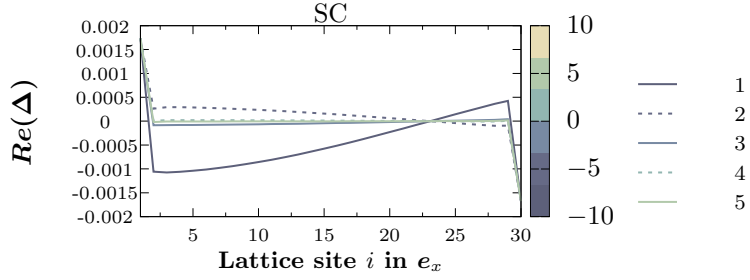
(a) Meanlines of  $\mu = -3.75$  not converging. Surrounded with vacuum for different  $\mu$ . Zero Phase  $\varphi = 117$  deg over 20 iterations.



(b) Meanlines of  $\mu = -4.75$  converging. Surrounded with vacuum for different  $\mu$ . Zero Phase  $\varphi = 117$  deg over 5 iterations.



(a) Meanlines of  $\mu = -3.75$  not converging. Surrounded with vacuum for different  $\mu$ . LinearGradient Phase  $\varphi = 117$  deg over 20 iterations.

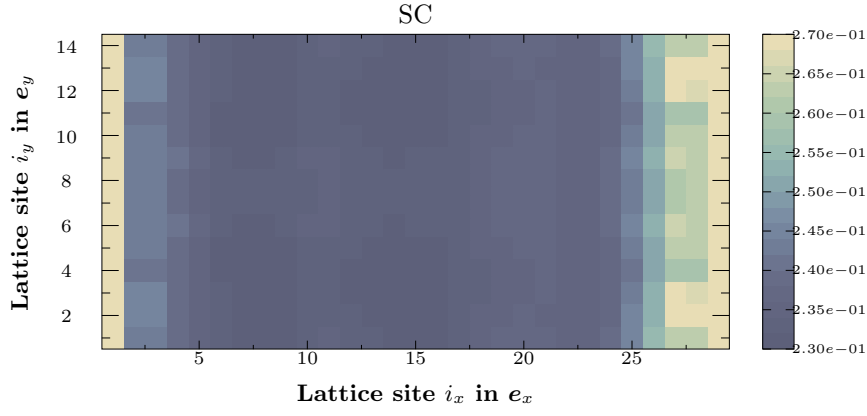


(b) Meanlines of  $\mu = -4.75$  not converging. Surrounded with vacuum for different  $\mu$ . LinearGradient Phase  $\varphi = 117$  deg over 5 iterations.

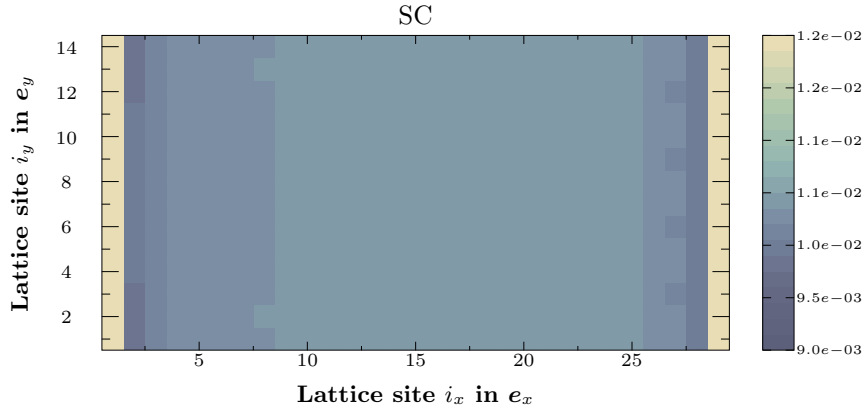
### 1.3 Contiuity of the current

#### 1.3.1 Fixed $\Delta$ on both sides

Zero Phase ..



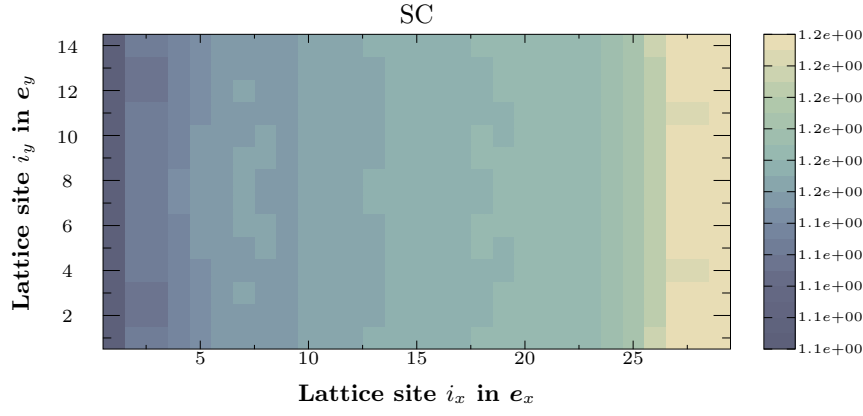
(a) Current continuity map. Surrounded with vacuum. Zero Phase  $\varphi = 117$  deg,  $\mu = 0.75$



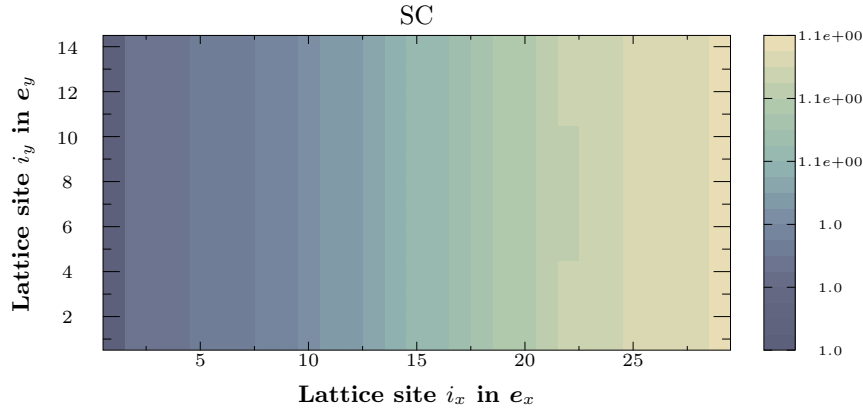
(b) Current continuity map. Surrounded with vacuum. Zero Phase  $\varphi = 117$  deg,  $\mu = -0.75$

**Figure 7:** Current continuity map  $J(i+1) - J(i-1) + J(i+N) - J(i-N)$ . Using a model where the phase is set to **zero everywhere but right and left side on the start**.

Linear Gradient ..



(a) Current continuity map Surrounded with vaccuum. LinearGradient Phase  $\varphi = 117 \text{ deg}$ ,  $\mu = 0.75$



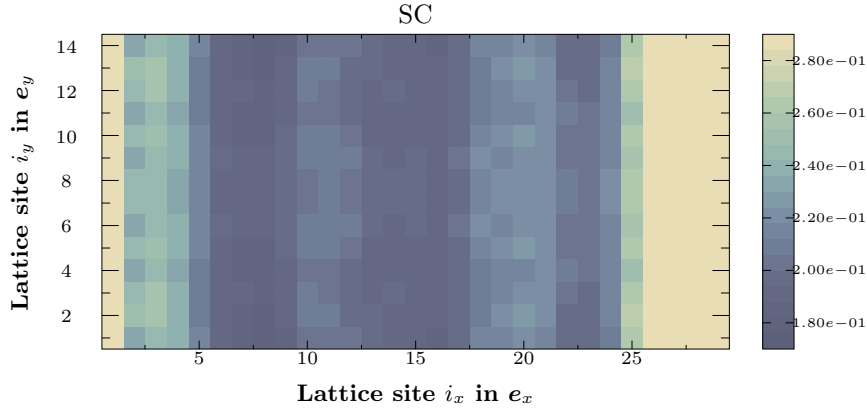
(b) Current continuity map. Surrounded with vaccuum. LinearGradient Phase  $\varphi = 117 \text{ deg}$ ,  $\mu = -0.75$

**Figure 8:** Current continuity map  $J(i + 1) - J(i - 1) + J(i + N) - J(i - N)$ . Using a model where the phase is set to be a **gradient from left to the right side** on the start.

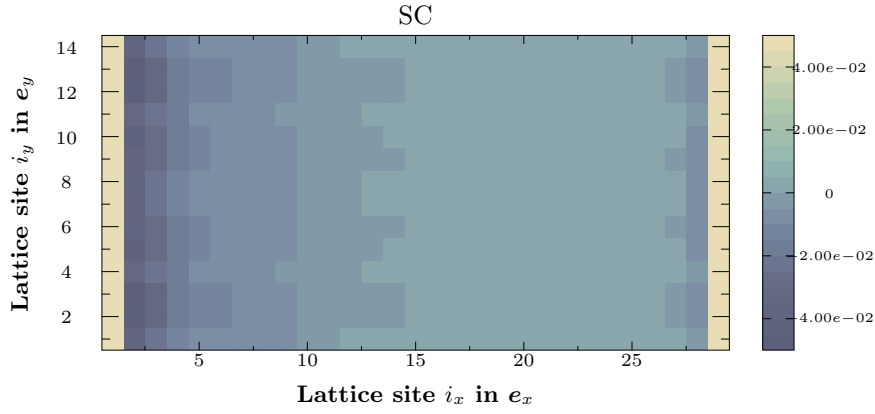
### 1.3.2 Fixed phase on both sides

Zero Phase ..





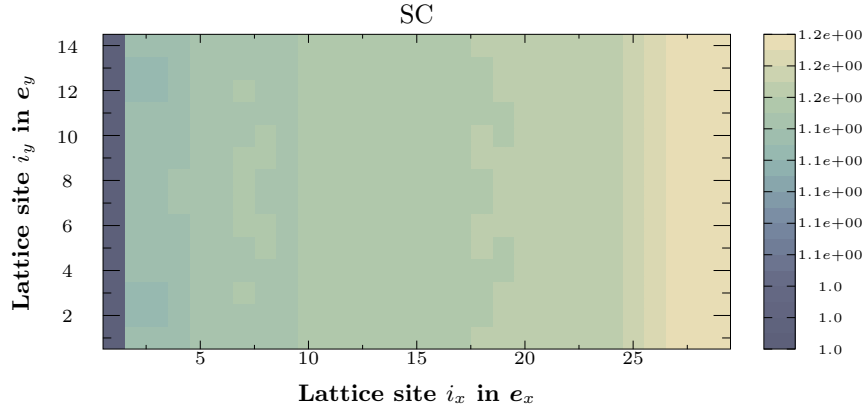
(a) Current continuity map. Surrounded with vacuum. Zero Phase  $\varphi = 117$  deg,  $\mu = 0.75$



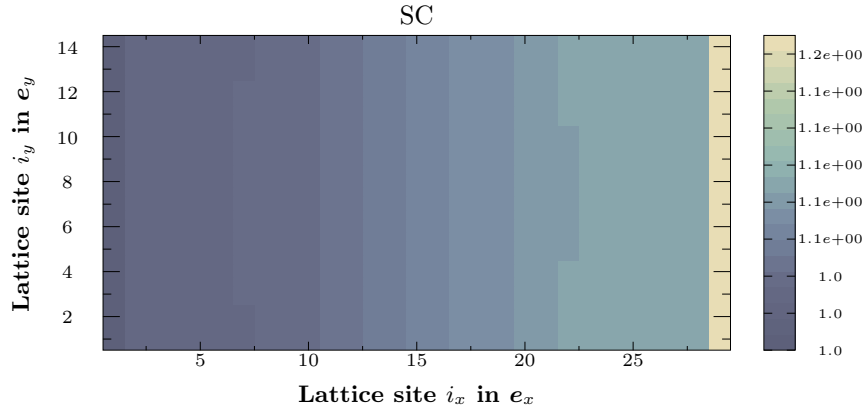
(b) Current continuity map. Surrounded with vacuum. Zero Phase  $\varphi = 117$  deg,  $\mu = -0.75$

**Figure 9:** Current continuity map  $J(i+1) - J(i-1) + J(i+N) - J(i-N)$ . Using a model where the phase is set to **zero everywhere but right and left side on the start**.

Linear Gradient ..



(a) Current continuity map Surrounded with vaccuum. LinearGradient Phase  $\varphi = 117 \text{ deg}$ ,  $\mu = 0.75$



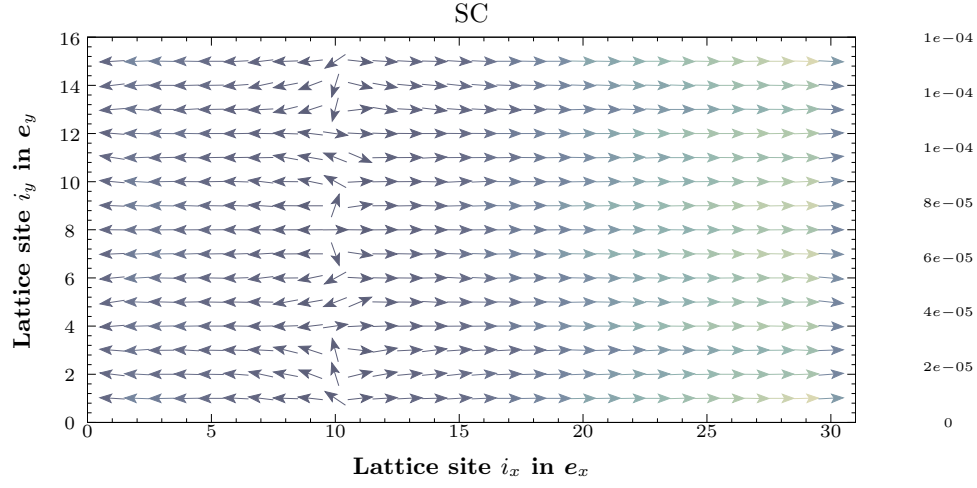
(b) Current continuity map. Surrounded with vaccuum. LinearGradient Phase  $\varphi = 117 \text{ deg}$ ,  $\mu = -0.75$

**Figure 10:** Current continuity map  $J(i+1) - J(i-1) + J(i+N) - J(i-N)$ . Using a model where the phase is set to be a **gradient from left to the right side** on the start.

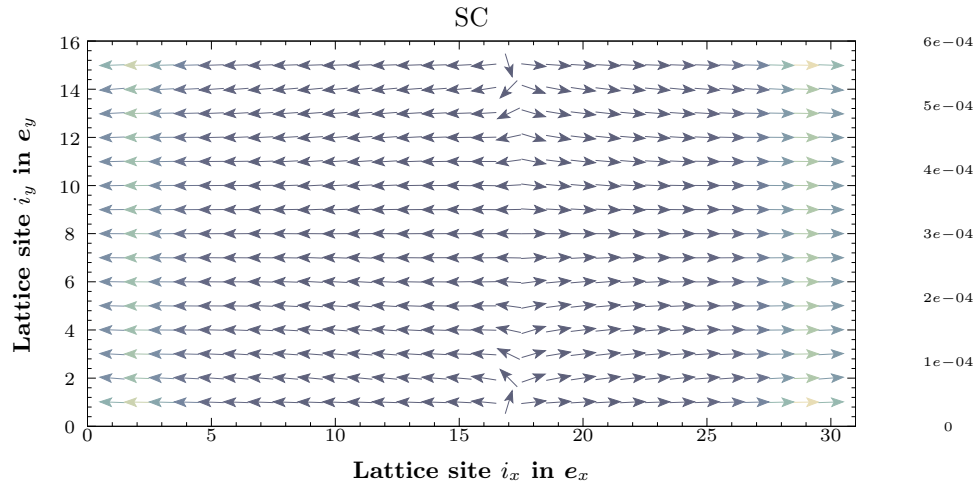
## 1.4 Current

### 1.4.1 Fixed $\Delta$ on both sides

Zero Phase ..



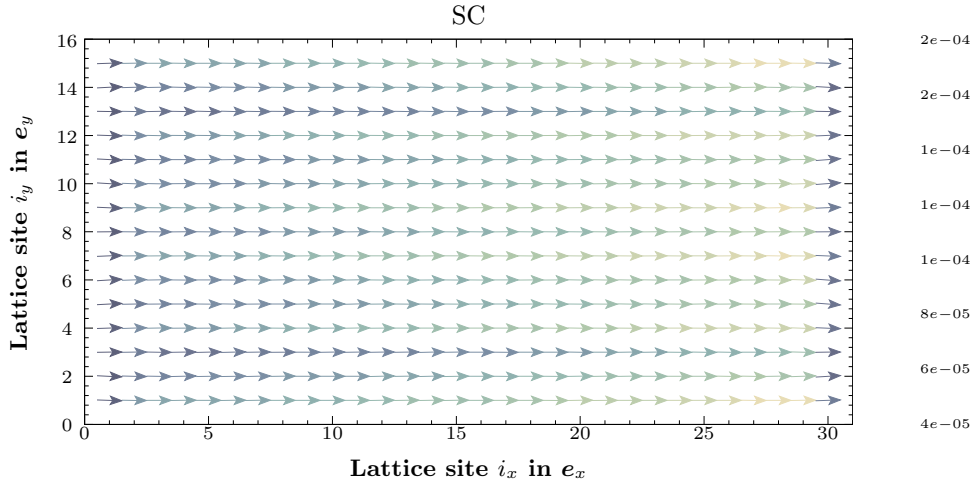
(a) Current map. Surrounded with vacuum. Zero Phase  $\varphi = 117$  deg,  $\mu = 0.75$



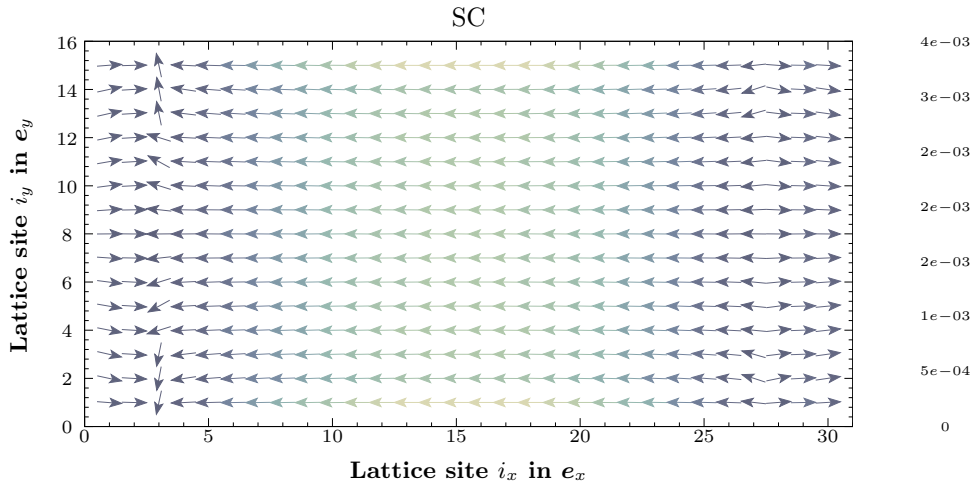
(b) Current map. Surrounded with vacuum. Zero Phase  $\varphi = 117$  deg,  $\mu = -0.75$

**Figure 11:** Current map. Using a model where the phase is set to **zero** erverywhere but **right and left side** on the start.

Linear Gradient ..



(a) Current map Surrounded with vacuum. LinearGradient Phase  $\varphi = 117 \text{ deg}$ ,  $\mu = 0.75$

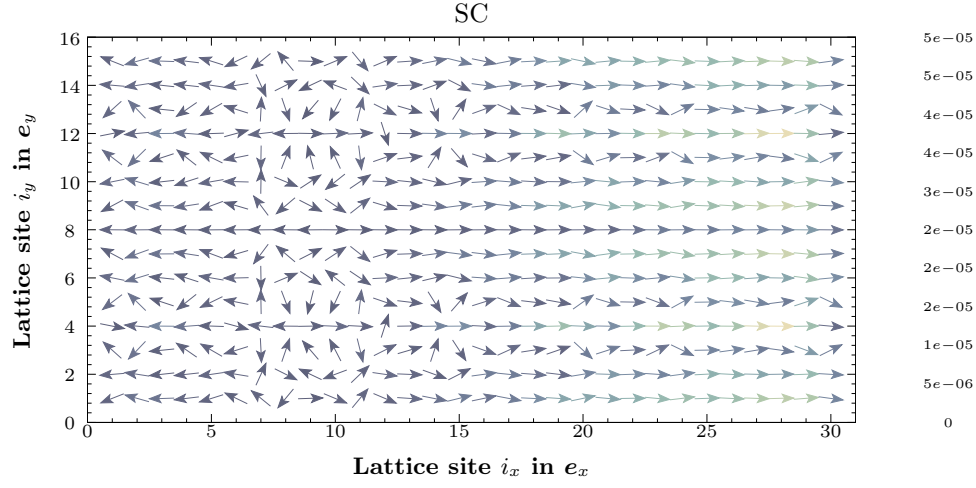


(b) Current map. Surrounded with vacuum. LinearGradient Phase  $\varphi = 117 \text{ deg}$ ,  $\mu = -0.75$

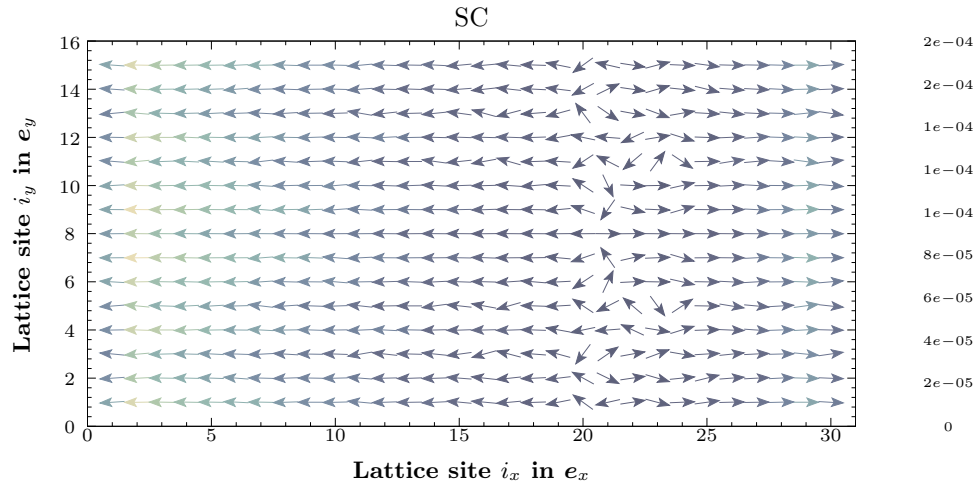
**Figure 12:** Current map . Using a model where the phase is set to be a **gradient from left to the right side** on the start.

#### 1.4.2 Fixed phase on both sides

Zero Phase ..



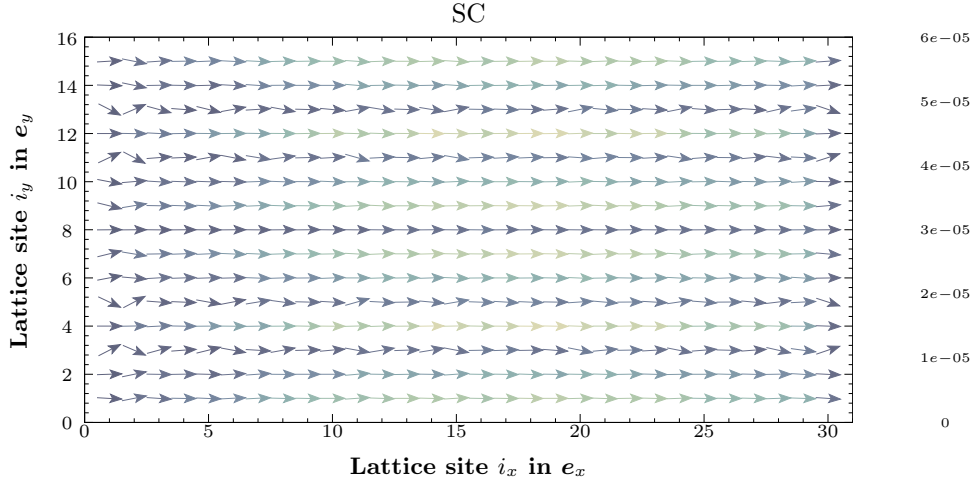
(a) Current map. Surrounded with vacuum. Zero Phase  $\varphi = 117$  deg,  $\mu = 0.75$



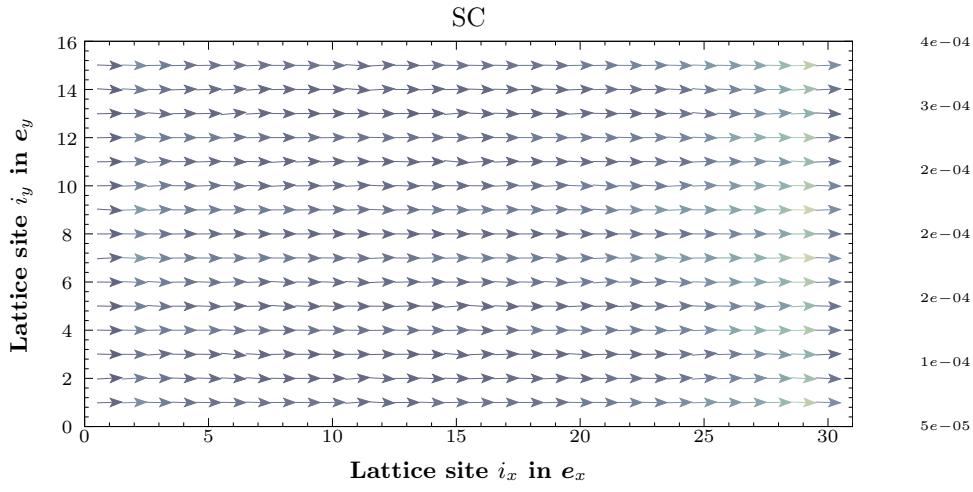
(b) Current map. Surrounded with vacuum. Zero Phase  $\varphi = 117$  deg,  $\mu = -0.75$

**Figure 13:** Current map. Using a model where the phase is set to **zero** erverywhere but **right** and **left** side on the start.

Linear Gradient ..



(a) Current map Surrounded with vacuum. LinearGradient Phase  $\varphi = 117$  deg,  $\mu = 0.75$



(b) Current map. Surrounded with vacuum. LinearGradient Phase  $\varphi = 117$  deg,  $\mu = -0.75$

**Figure 14:** Current map . Using a model where the phase is set to be a **gradient from left to the right side** on the start.

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