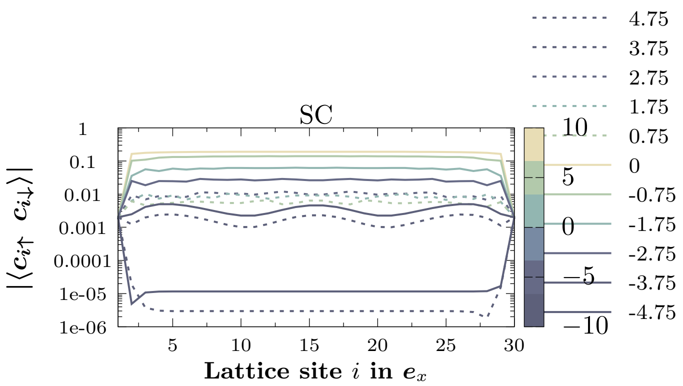
1 Benchmark on SC30

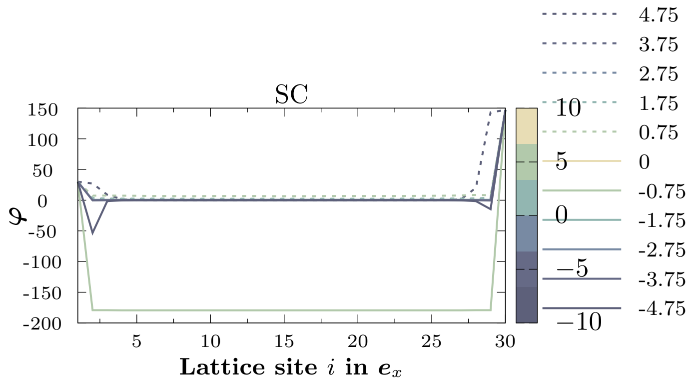
1.1 Length and arguement for different μ

1.1.1 Fixed Δ on both sides

Zero Phase ..



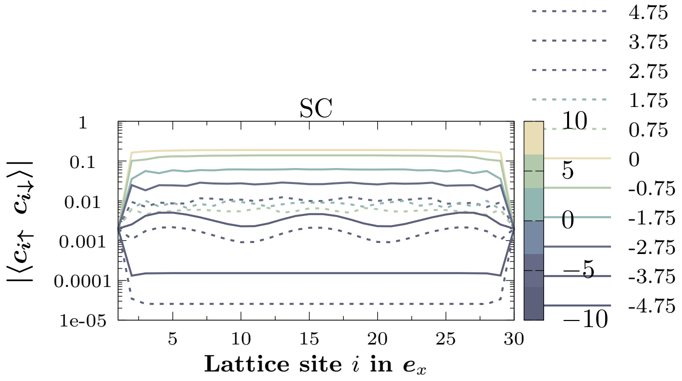
(a) Meanline. Surrounded with vaccuum for different mu. Zero Phase $\varphi = 117\,\mathrm{deg}$



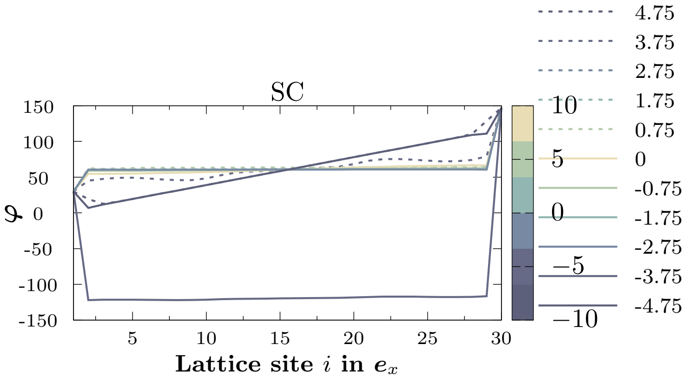
(b) Meanline of the phase. Surrounded with vaccuum for different mu. Zero Phase $\varphi = 117\,\mathrm{deg}$

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 vaccuum for different mu. Phase Gradient $\varphi = 117\,\text{deg}$



(b) Meanline of the phase. Surrounded with vaccuum for different mu. Phase Gradient $\varphi = 117\,\text{deg}$

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

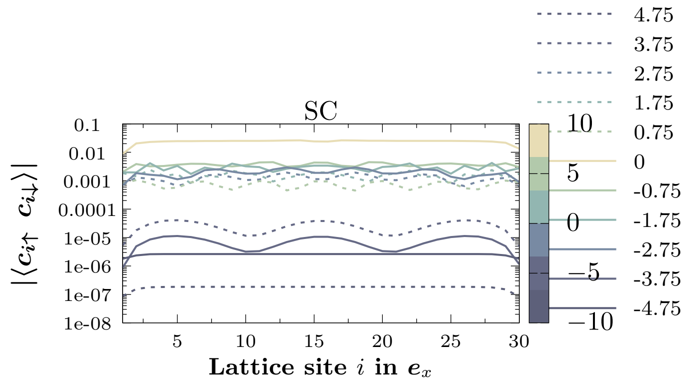
The ability of the system to form Cooper pairs is heigher when the chemical potential approaches zero and reach a minimum whene $|\mu|$ get far from zero. According to `https://abhirup-m.github.io/assets/pdfs/tbm.pdf` when μ is positive, we fill up the band. We are going to stay with a filled band This $|\mu|$-dependence can be understood as follow. 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 become 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 alternates between its positive and negative value in the real part. This means the phase drop we have isn't realy a result, depending on when we stop, we get -120 or $-120 + 180 = 60$ which lays 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

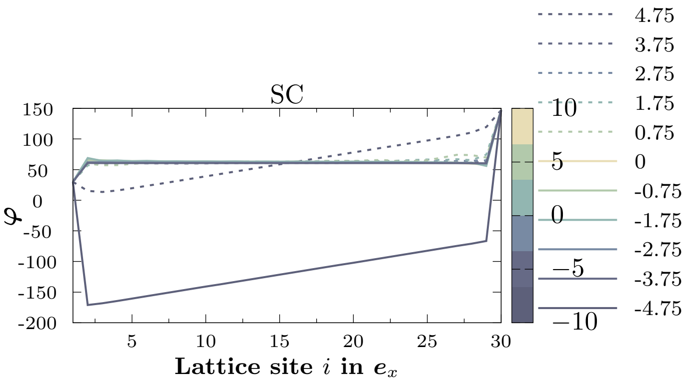
and then jumps at the end. The heigher the $|\mu|$, the more the gradient is observable.

1.1.2 Fixed phase on both sides

Linear Gradient ..



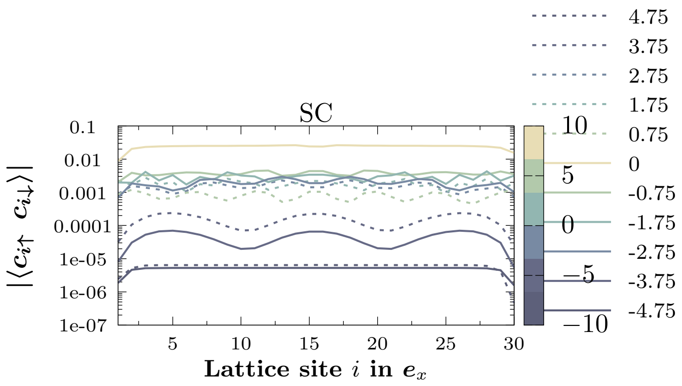
(a) All mean line. Surrounded with vaccuum. LinearGradient Phase φ = 117 deg.



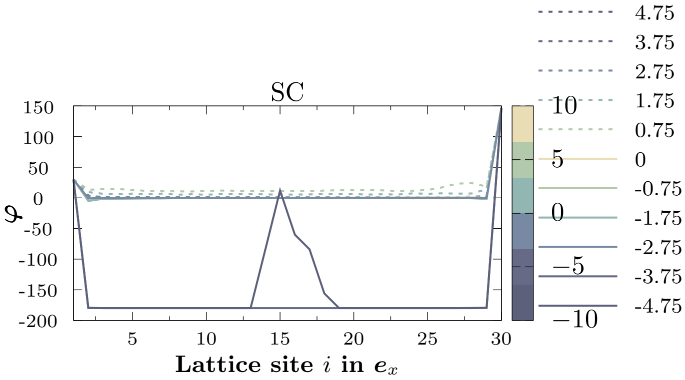
(b) Phase mean line. Surrounded with vaccuum. LinearGradient Phase φ = 117 deg.

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 vaccuum. ZeroPhase Phase $\varphi = 117$ deg.



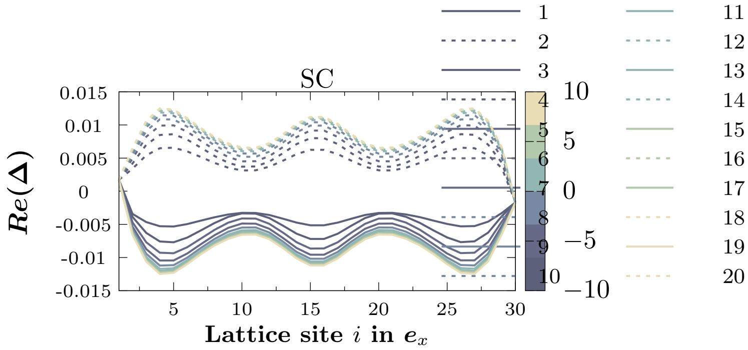
(b) Phase mean line. Surrounded with vaccuum. ZeroPhase Phase $\varphi = 117$ deg.

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

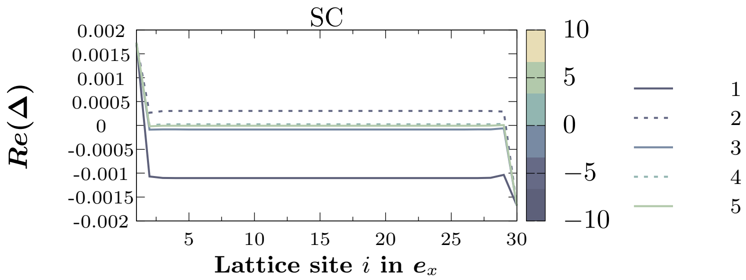
1.2 Convergence of the meanline

This section shows how the meanline converges for different μ and different phase setup. The key point is to see that $\mu = -3.75$ doesn't and then oscillates arround 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 oand the zero phase.

Zero Phase ..

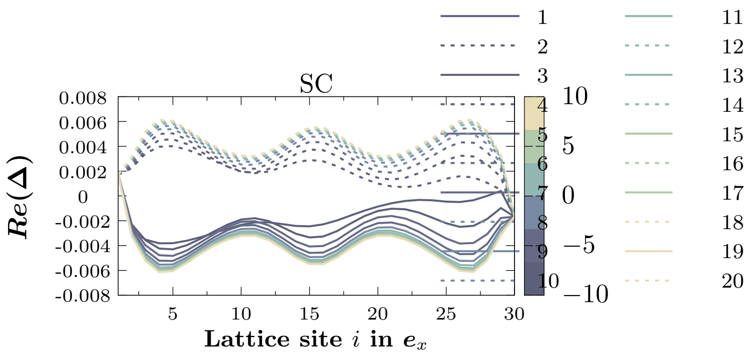


(a) Meanlines of $\mu = -3.75$ not converging. Surrounded with vaccuum for different mu. Zero Phase $\varphi = 117\,\mathrm{deg}$ over 20 iterations.

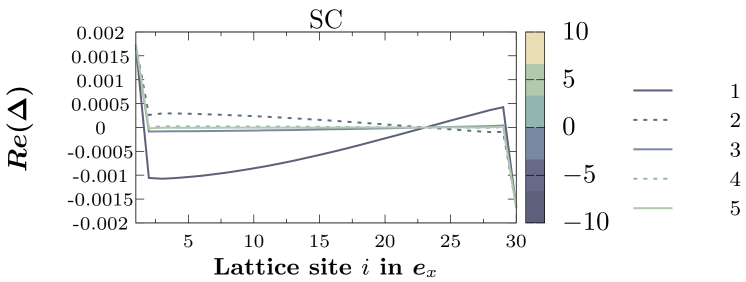


(b) Meanlines of $\mu = -4.75$ converging. Surrounded with vaccuum for different mu. Zero Phase $\varphi = 117\,\mathrm{deg}$ over 5 iterations.

Linear Gradient ..



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



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

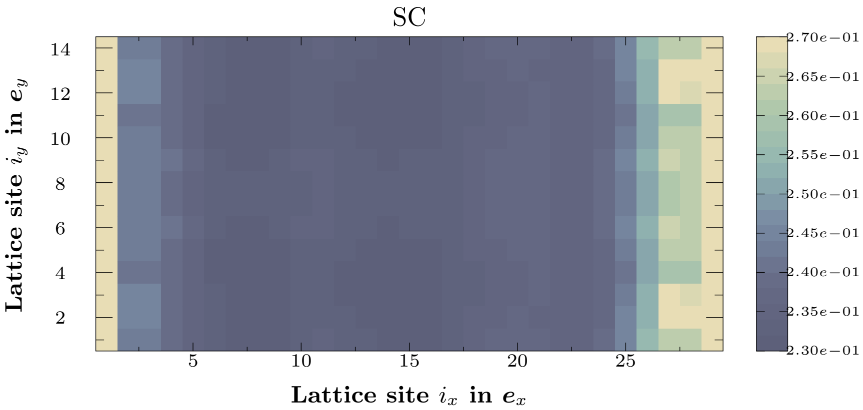
1.3 Contiuity of the current

In the two last sesction we will notice how the phase plays an important role in the currents direction and strength. We we have a zero phase, there are two direction the current can take. From zero to $\pi/6$rad and from 0 zero to $\pi/6$rad +117deg. For this reason we observe two flows of current. Further the magnetude of the phase transition makes the current stronger. For instance the current in the first case is weaker than when the phase jumps to $\pi/6+117$deg.Therfore the most promissing results lays in the phase gradient, which is the most realistic case. However using a fixed Δ leads to a stronger value in the continuity map than for the fixed phase.

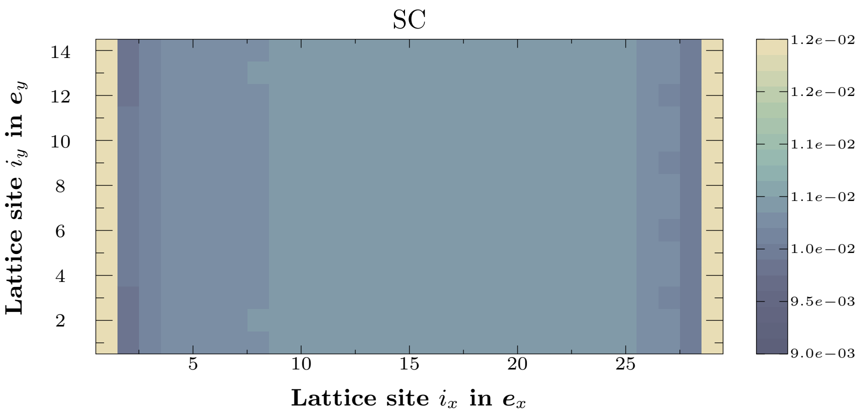
The most promissing results may lay in the two last graphs.

1.3.1 Fixed Δ on both sides

Zero Phase ..



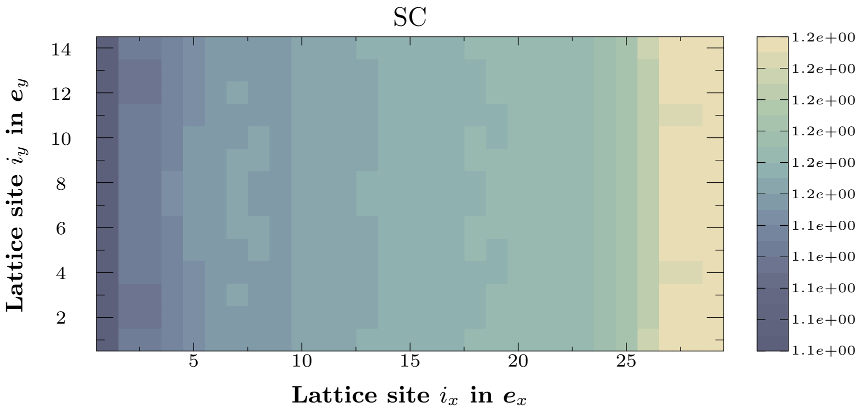
(a) Current continuity map. Surrounded with vaccuum. Zero Phase $\varphi = 117\,\mathrm{deg}$, $\mu = 0.75$



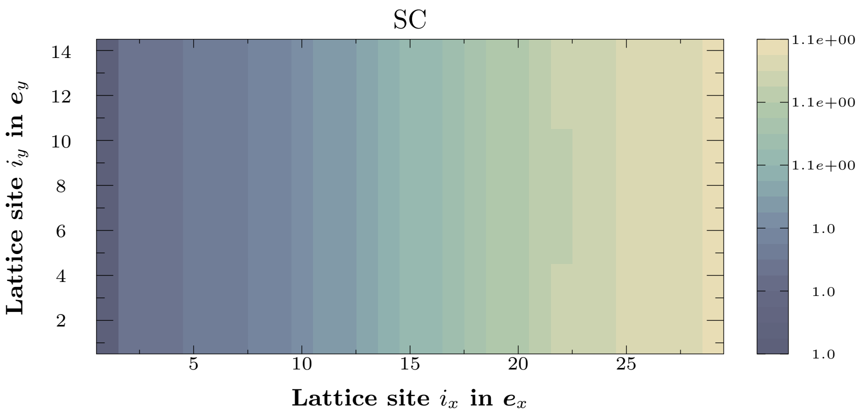
(b) Current continuity map. Surrounded with vaccuum. Zero Phase $\varphi = 117\,\mathrm{deg}$, $\mu = -0.75$

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 erverywhere but right and left side** on the start.

Linear Gradient ..



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

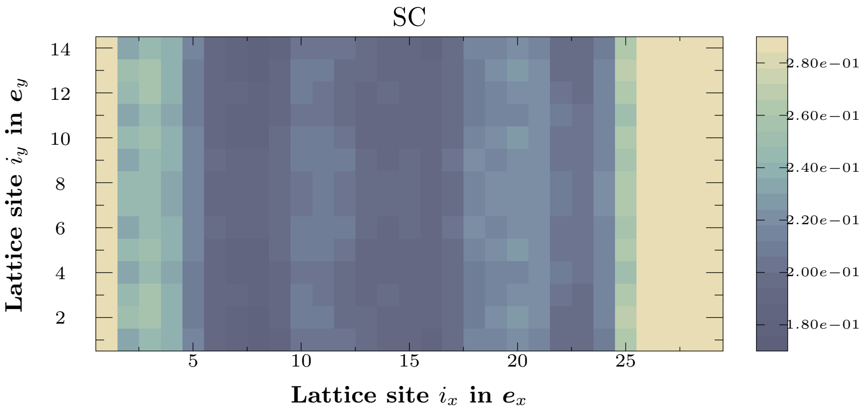


(b) Current continuity map. Surrounded with vaccuum. LinearGradient Phase $\varphi = 117\,\text{deg}$, $\mu = -0.75$

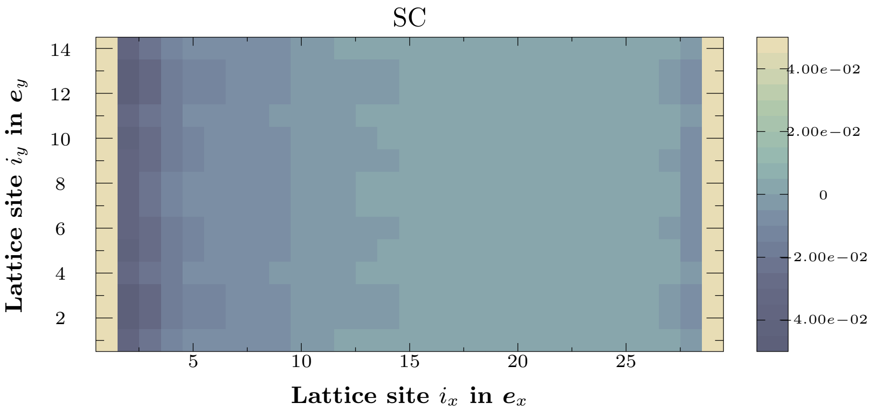
Figure 8: Current continuity map $J(i+1) - J(i-1) + J(i+N) - J(i-N)$. Using a model where the phase is set to be a **gradient from left to the right side** on the start.

1.3.2 Fixed phase on both sides

Zero Phase ..



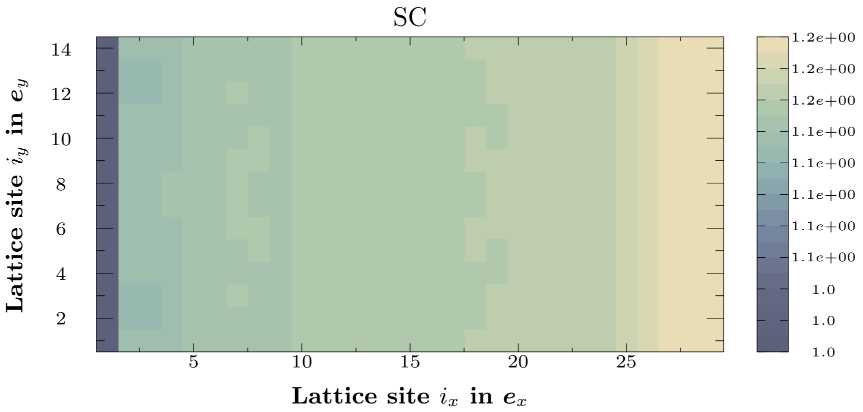
(a) Current continuity map. Surrounded with vaccuum. Zero Phase $\varphi = 117\,\text{deg}$, $\mu = 0.75$



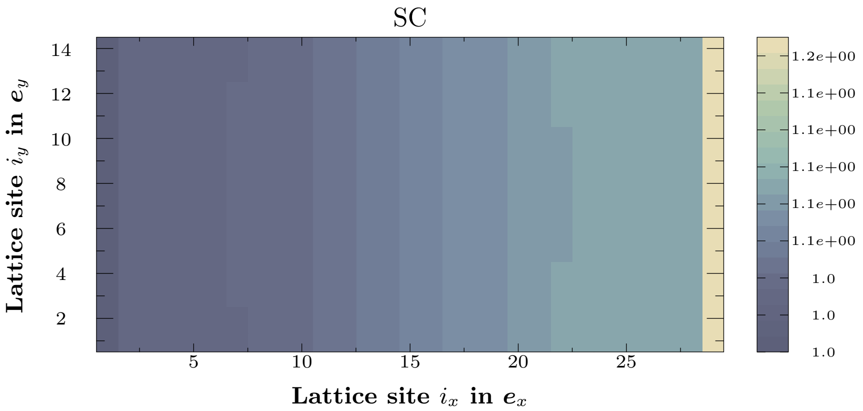
(b) Current continuity map. Surrounded with vaccuum. Zero Phase $\varphi = 117\,\text{deg}$, $\mu = -0.75$

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 erverywhere but right and left side** on the start.

Linear Gradient ..



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



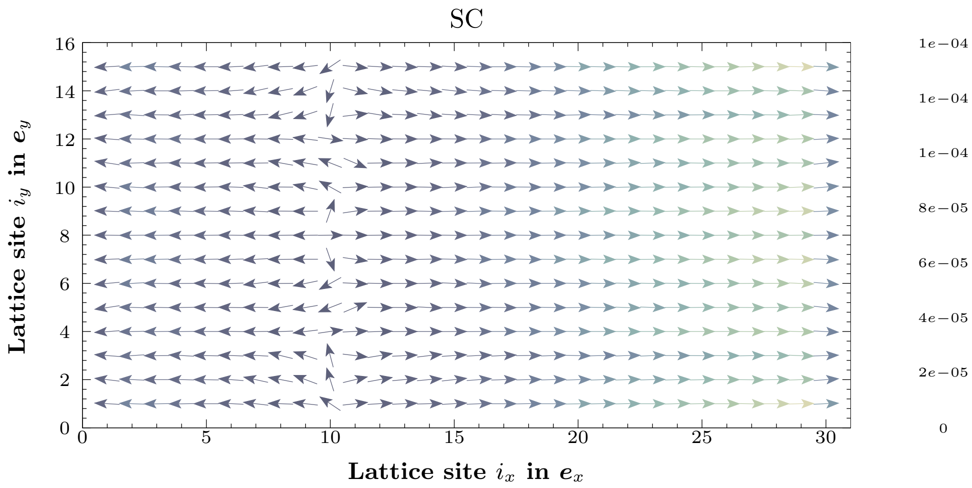
(b) Current continuity map. Surrounded with vaccuum. LinearGradient Phase $\varphi = 117\,\mathrm{deg}$, $\mu = -0.75$

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.

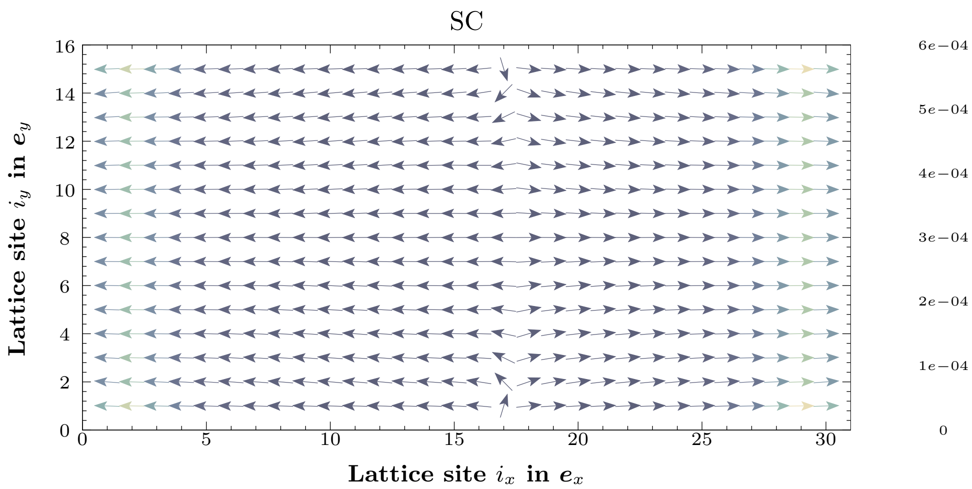
1.4 Current

1.4.1 Fixed Δ on both sides

Zero Phase ..



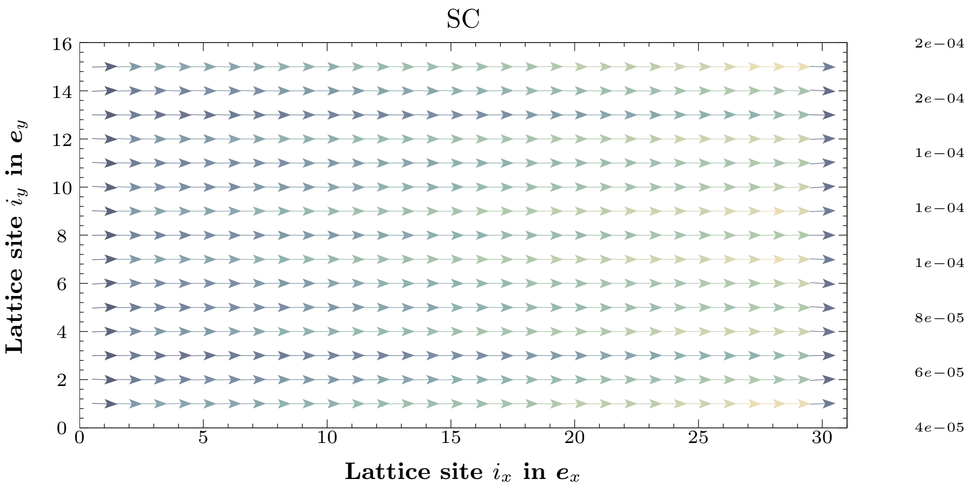
(a) Current map. Surrounded with vaccuum. Zero Phase $\varphi = 117\,\text{deg}$, $\mu = 0.75$



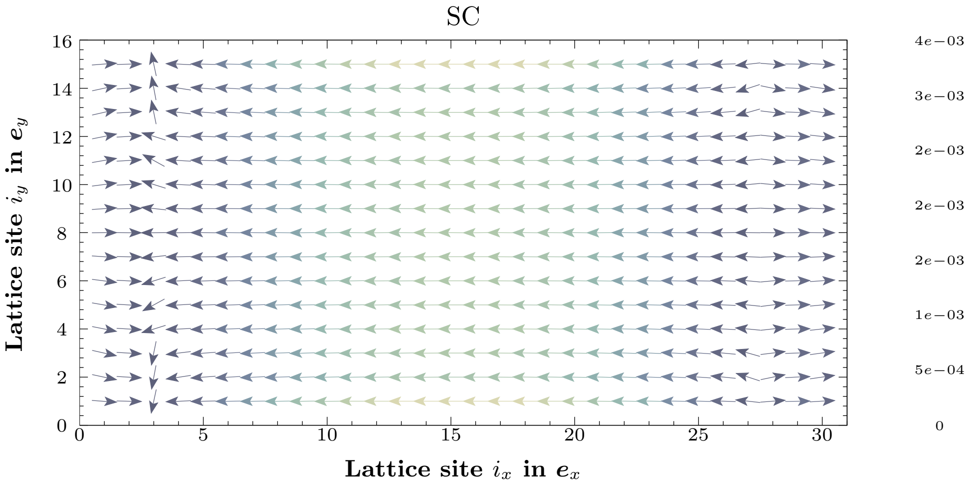
(b) Current map. Surrounded with vaccuum. Zero Phase $\varphi = 117\,\text{deg}$, $\mu = -0.75$

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 vaccuum. LinearGradient Phase $\varphi = 117\,\text{deg}$, $\mu = 0.75$

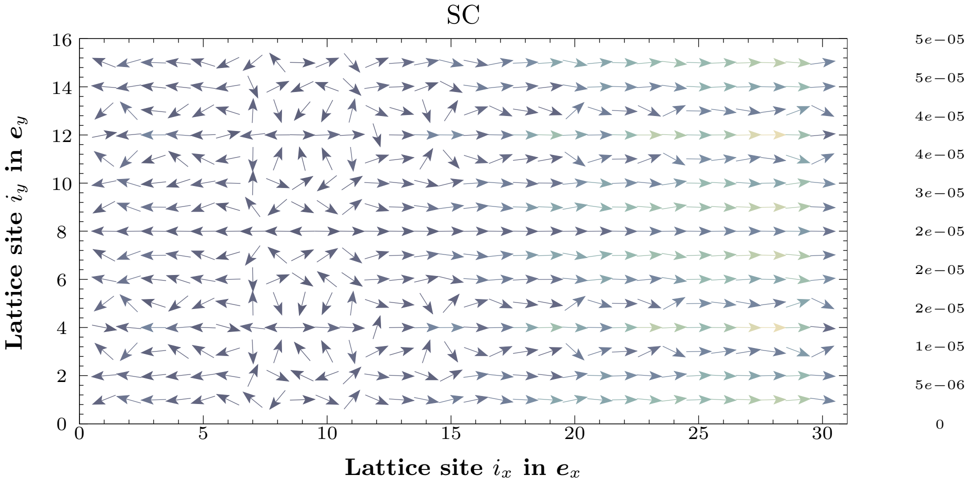


(b) Current map. Surrounded with vaccuum. LinearGradient Phase $\varphi = 117\,\text{deg}$, $\mu = -0.75$

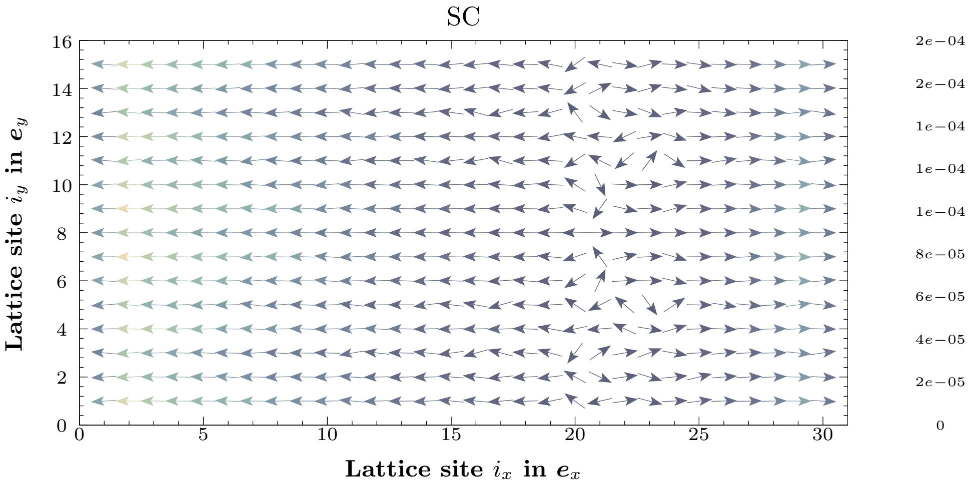
Figure 12: Current map . Using a model where the phase is set to be a **gradient from left to the right side** on the start.

1.4.2 Fixed phase on both sides

Zero Phase ..



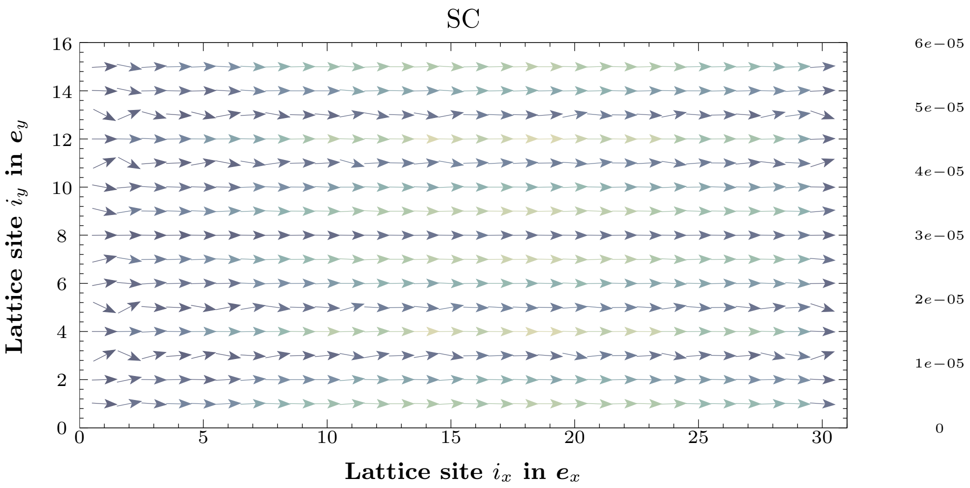
(a) Current map. Surrounded with vacuum. Zero Phase $\varphi = 117\,\text{deg}$, $\mu = 0.75$



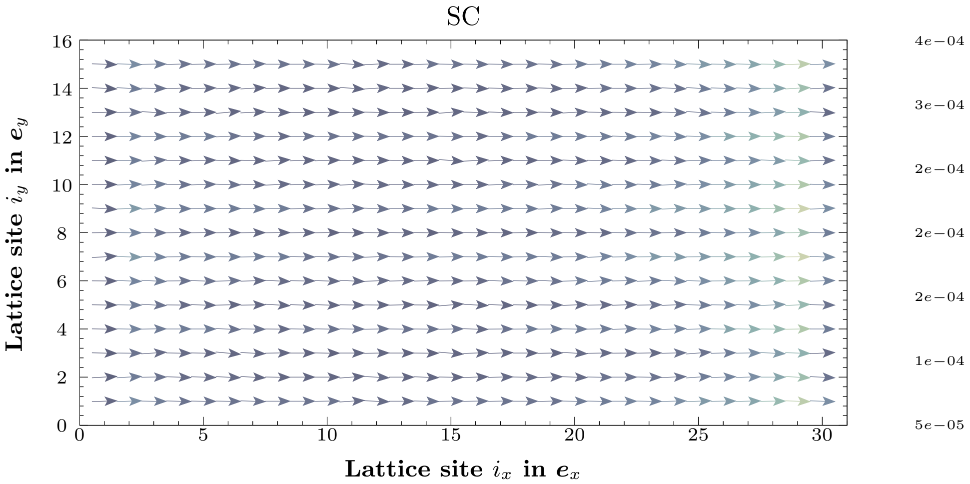
(b) Current map. Surrounded with vacuum. Zero Phase $\varphi = 117\,\text{deg}$, $\mu = -0.75$

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 vaccuum. LinearGradient Phase $\varphi = 117\,\text{deg}$, $\mu = 0.75$



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

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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