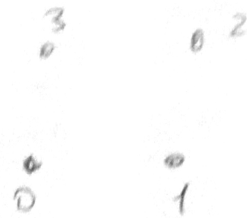
0 = (0,0)
1 = (a,0)
2 = (a,a)
3 = (0,a)



$$\sum_j S^z_j e^{-iqj} \overset{q=\pi}{=} S^z_0 + S^z_1 e^{-i\pi} + S^z_2 e^{-i(\pi+\pi)} + S^z_3 e^{-i\pi} = S^z_0 - S^z_1 + S^z_2 - S^z_3$$

$\to S^z_{(\pi,\pi)}$

$$S^z_j = (c^\dagger_{j\uparrow} c_{j\uparrow} - c^\dagger_{j\downarrow} c_{j\downarrow})$$

$0 = \uparrow \quad 1 = \downarrow$

colonna 5

0 : $cc^\dagger$

1 : $c^\dagger c$

$$S^z_0 = \frac{1}{2}(c^\dagger_{0\uparrow} c_{0\uparrow} - c^\dagger_{0\downarrow} c_{0\downarrow})$$
$$S^z_1 = \frac{1}{2}(c^\dagger_{1\uparrow} c_{1\uparrow} - c^\dagger_{1\downarrow} c_{1\downarrow})$$
$$S^z_2 = \frac{1}{2}(c^\dagger_{2\uparrow} c_{2\uparrow} - c^\dagger_{2\downarrow} c_{2\downarrow})$$
$$S^z_3 = \frac{1}{2}(c^\dagger_{3\uparrow} c_{3\uparrow} - c^\dagger_{3\downarrow} c_{3\downarrow})$$

pauileft 2x2 Heisenberg

	i	σ_1	j	σ_2	Tipo $c^\dagger c$ o $cc^\dagger$	Re (ecc.)	Im (ecc.)
S^z_0	0	0	0	0	1	+ 1/2	0
	0	1	0	1	1	− 1/2	0
$-S^z_1$	1	0	1	0	1	− 1/2	0
	1	1	1	1	1	+ 1/2	0
S^z_2	2	0	2	0	1	+ 1/2	0
	2	1	2	1	1	− 1/2	0
S^z_3	3	0	3	0	1	− 1/2	0
	3	1	3	1	1	+ 1/2	0