We aim to expand current probes on Self-Interacting Dark Matter (SIDM) models. For this, we estimate the expected signal on the Super-Kamiokande (SK) telescope expanding current limits to lower dark matter masses. Our results were derived by comparing our estimated number of upward muon events in the detector with those of the SK collaboration. Given the self-interaction of dark matter, the number of neutrinos from the Sun will be greater than for CDM without collisions. We analyzed the neutrinos from the annihilation channels in \(W^+W^-\) and \(b\bar{b}\). The signal obtained in this analysis is consistent with the background of atmospheric muons, therefore, no significant excess of ascending muons induced by neutrinos from the Sun was found. Thus, our results excluded a significant region of SIDM models. The channels of annihilation considered, include more energetic neutrinos coming from the channel \(W^+W^-\) and less energetic of the channel \(b\bar{b}\). Given the low energy threshold of SK, when compared to the IceCube telescope, we obtained more stringent results for the channel \(b\bar{b}\). This is due to the fact that SK energy threshold is lower than IceCube's.

**Motivation:**
We tested SIDM because it could solve cosmological problems on small scales like “Cusp-Core Problem”, “Missing Satellites Problem” and “Too Big To Fail Problem”.

**SIDM effects on indirect detection:**
- It increases the capture rate of DM particles in the Sun.
- It increases the annihilation rate of DM particles in the Sun.
- It accelerates the equilibrium between the capture and annihilation processes.
- It leads to an improvement in the detected neutrino signal.

**Our results:**
We calculate the temporal evolution of the number of DM particles captured. The three terms on the right are the capture rate with and without self-interactions and the annihilation rate.

\[
\frac{dN_t}{dt} = \Gamma_C + 2\Gamma_a - 2\Gamma_a,
\]

**CONCLUSIONS**
1) We simulate SIDM, being captured in the Sun and annihilating itself in the nucleus. We determine and compare the estimated number of muon events with the upper limit of SK Collaboration Events.
2) We exclude 90% C.L. several SIDM models, considered as potential solutions to CDM problems on small scales.
3) We established the new interval, \(\sigma_{\chi}\rho_{\chi} \approx \{0.7, 1.3\} \times 10^{-40} \text{ cm}^2/\text{g}\) for m\(\chi\) are the ratio if the DM annihilates in \(W^+W^-\) with \(\chi^2/\nu_{\alpha}\) of
4) We established the strictest upper limit of exclusion, at 90% C.L., in \(\sigma\chi\rho\chi\) for m\(\chi\) = 100 GeV/c^2, with an effective area of the detector, being theta zenith angle.

**Figure 1.** Left. Simulated CDM halo with \(10^{12}\) M. In circles, the nine most massive subhalos of the Milky Way. Right. Comparison of the density profiles of a halo in CDM and SIDM.

**Figure 2.** Temporal evolution of the number of DM particles captured in the Sun. The continuous curves are obtained without considering the capture rate due to self-interactions, the discontinuous curves if they consider this term. The graphs are for different values of the cross-section of self-interaction \([1]\).