Relevance of the Kohn-Luttinger Effect for Superfluidity in Neutron Stars

Mia Lavender Kumamoto
Pronouns: she/her

IReNA-INT workshop 12/10/24

Based on Phys. Rev. C **110,** 025804 [arXiv:2405.12243] (MK, Reddy 2024)

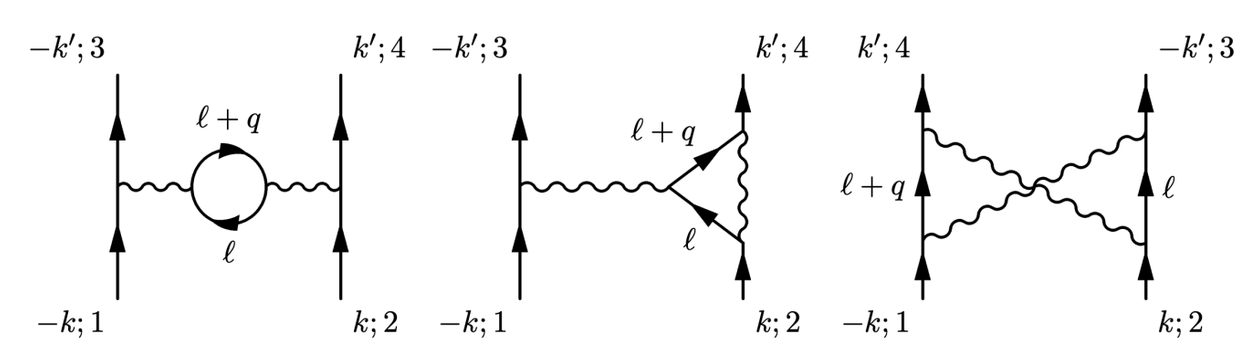
What is the Kohn-Luttinger effect?

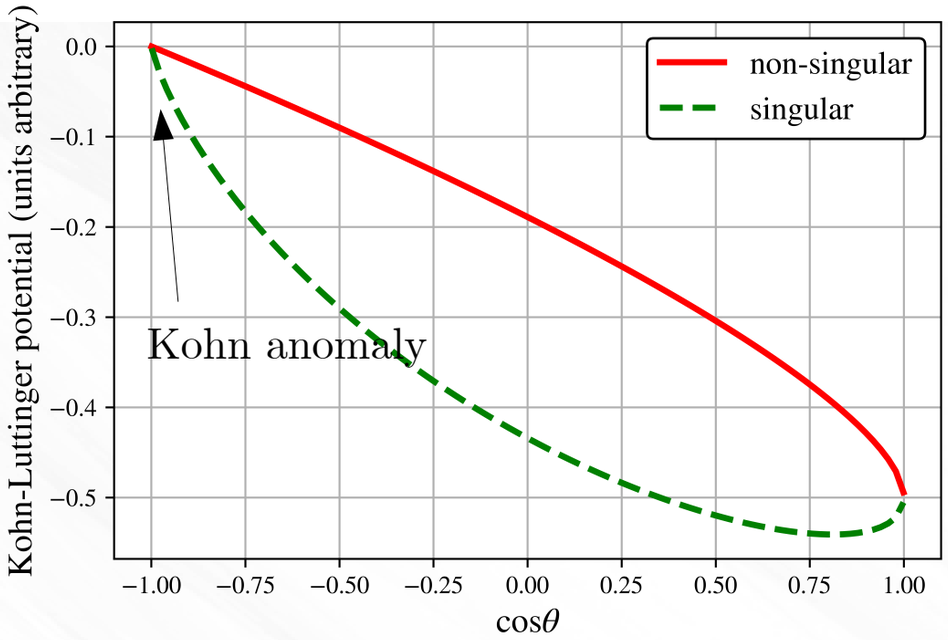
- Medium effects overscreen any generic potential, leading to a singularity near $q=2k_F$ (the "Kohn anomaly")
- Singular contributions lead to attraction in large odd partial waves. (Kohn + Luttinger Phys. Rev. Lett. 15, 524)

$$\text{Non-singular: } \propto e^{-L}$$

$$\text{Singular: } \propto (-1)^L L^{-4}$$

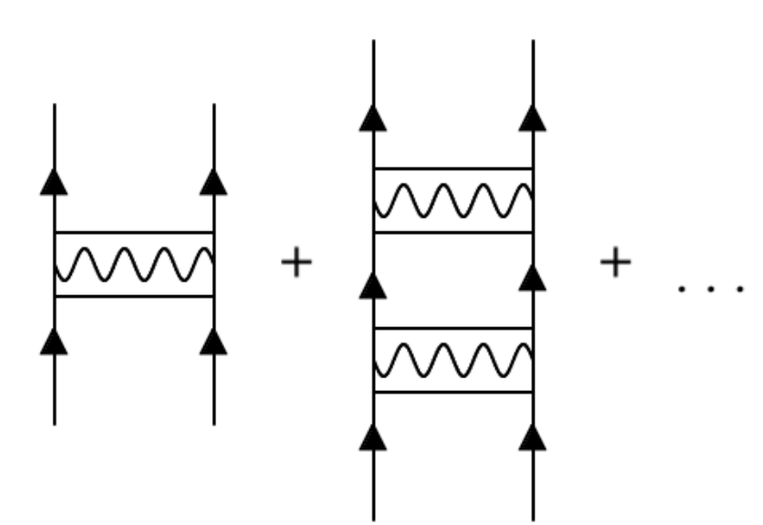
- While generically true only for large L, this effect persists for many potentials for L=1.





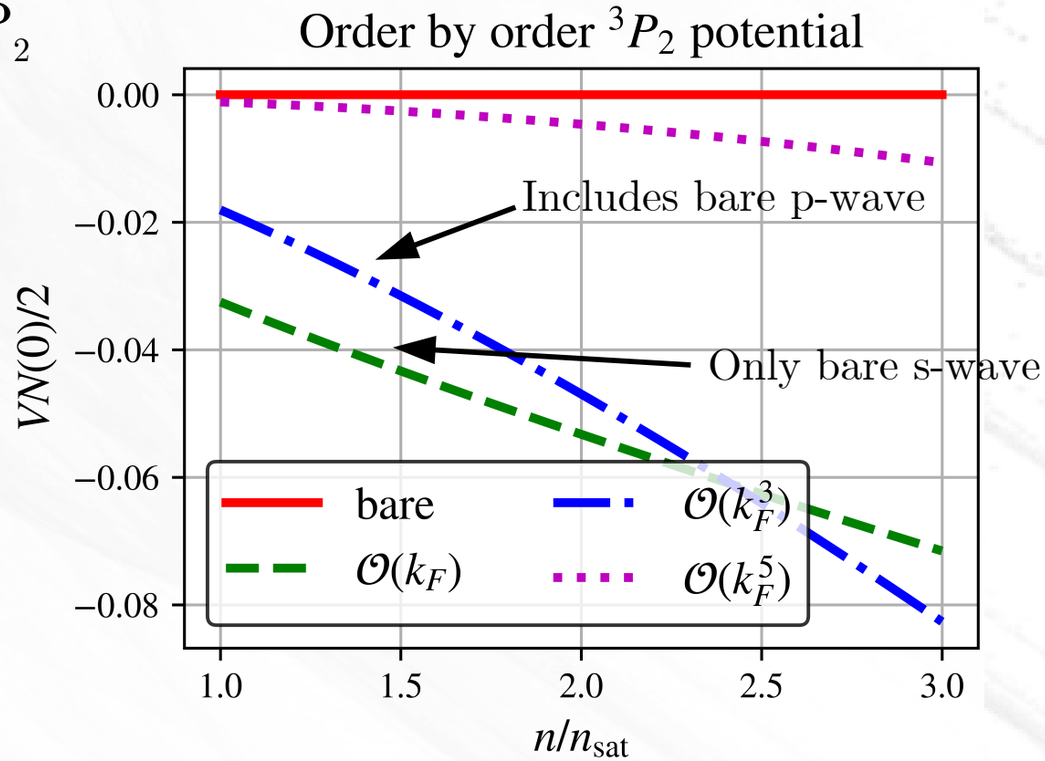
If you don't think about this often...

- In the BCS approximation, the superfluid gap comes from summing over the "ladder" diagrams.
- Any contribution to the *irreducible* vertex will contribute in the BCS approximation and should be included.
- Generic nuclear potentials will have contributions from multiple partial waves at tree level which the Kohn-Luttinger (one loop) potential must compete with.



When might the Kohn-Luttinger effect matter?

- Short range, Lorentz invariant, non-derivative couplings (e.g. NJL models) can't generate any $^3P_2$ potential at tree level.
- The one loop calculation might be important!
- Typical nuclear potentials will have bare p-wave contributions which do not rely on the Kohn anomaly to contribute and are less suppressed.
- TAKEAWAY: The one loop interaction can be important and naive power counting with momentum may get the relative importance of different contributions wrong.



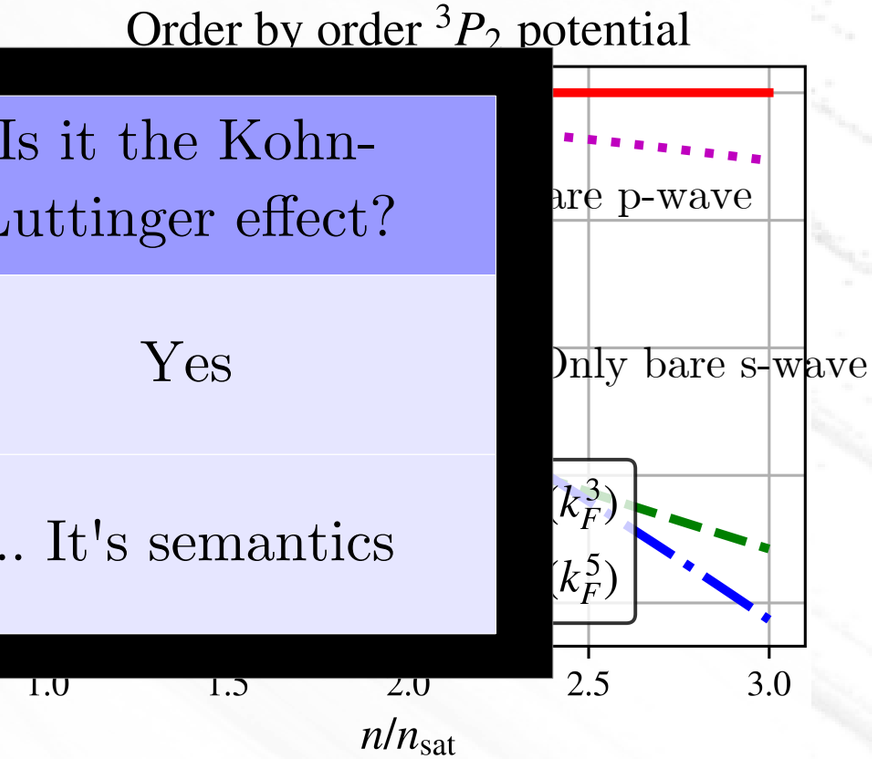
$$\mathcal{L}_{\rm int} = -\frac{G_V}{2}(\bar{n}\gamma^\mu n)^2$$

When might the Kohn-Luttinger effect matter?

- Short range, Lorentz invariant, non-derivative couplings (e.g. NJL models) can't generate any $^3P_2$ p
- T
- T
  c
  a
- T
  i

momentum may get the relative importance of different contributions wrong.

	Is it important to $^3P_2$?	Is it the Kohn-Luttinger effect?
Bare s-wave, one loop	Probably not	Yes
Bare p-wave, one loop	Probably yes	... It's semantics



$$\mathcal{L}_{\rm int} = -\frac{G_V}{2}(\bar{n}\gamma^\mu n)^2$$