Equation of state with induced surface tension

Neutron star cooling within the equation of state with induced surface tension

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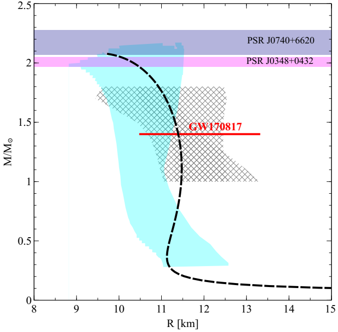
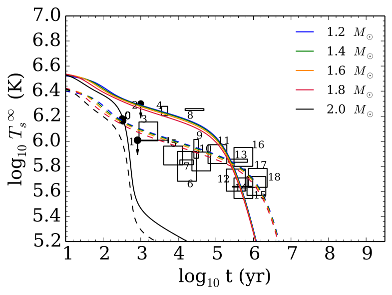
IWARA From Quarks to Cosmos



EoS with induced surface tension (IST EoS)
consistent with:
nuclear matter ground state properties:
$E_{sym} = 30.0\ MeV$, $L = 93.2\ MeV$,
$K_0 = 201.0\ MeV$,
proton flow data,
heavy-ion collisions data,
astrophysical observations,
tidal deformability constraint from the NS-NS merger (GW170817)

VS, I. Lopes, A. Ivanytskyi, ApJ, 871, 157 (2019)
VS, A. Ivanytskyi, K. Bugaev, et al., Nucl. Phys. A, 924, 24 (2014)

no pairing

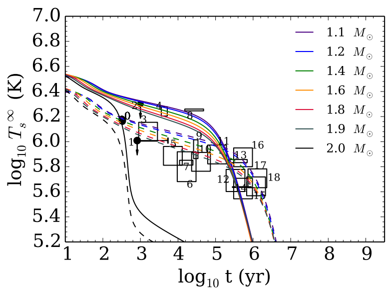


Tsiopelas, S., VS, arXiv:2006.06351 [astro-ph.HE] (2020)

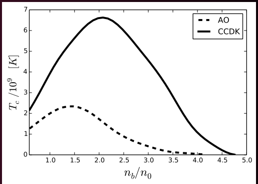
Envelope models:

- composed of heavy elements (Fe) $\Longrightarrow$ Dashed curves
- composed of light elements (H) equal to $\eta = \Delta M/M = 10^{-7} \Longrightarrow$ Solid curves
  Potekhin, A. Y. et al., Astrophys. J., 594, 1, 404 (2003)

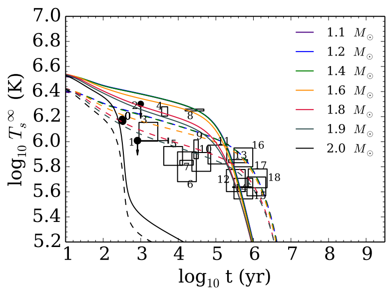
$n\ ^1S_0$ superfluidity (SFB model) + $p\ ^1S_0$ superconductivity (AO model)



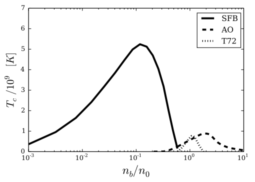
proton pairing gaps



$n\ ^1S_0$ superfluidity (SFB model) + $p\ ^1S_0$ superconductivity (CCDK model)



neutron pairing gaps



Tsiopelas, S., VS, arXiv:2006.06351 [astro-ph.HE] (2020)

Conclusions

- The obtained cooling curves for unpaired matter are in good agreement with observational data. Cas A can be equally described by both a rapidly cooling $2\,M_\odot$ star with a light-elements envelope and a slow cooling low-mass star with a Fe envel.
- Including n $^1S_0$ superfluidity and p $^1S_0$ super conductivity in our simulations, we concluded that both considered combinations of gaps (SFB+AO, SFB+CCDK) result in cooling curves that are able describe the observational data. In addition, the former one offers the same two ways of interpreting Cas A with the case of unpaired matter.
- Introducing n $^3P_2$ superfluidity in our calculations, using both a model with a shallow gap (T72) and one with an extended gap (AO), led to a more rapid cooling of the stars. This rendered the obta ined cooling curves incompatible with most of the observations, and thus neutron pairing in the triplet channel inconsistent with observational data within our model.