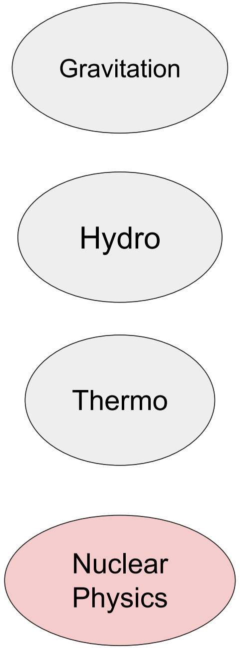
Nuclear parameter inference in the context of high precision detections of Neutron Stars

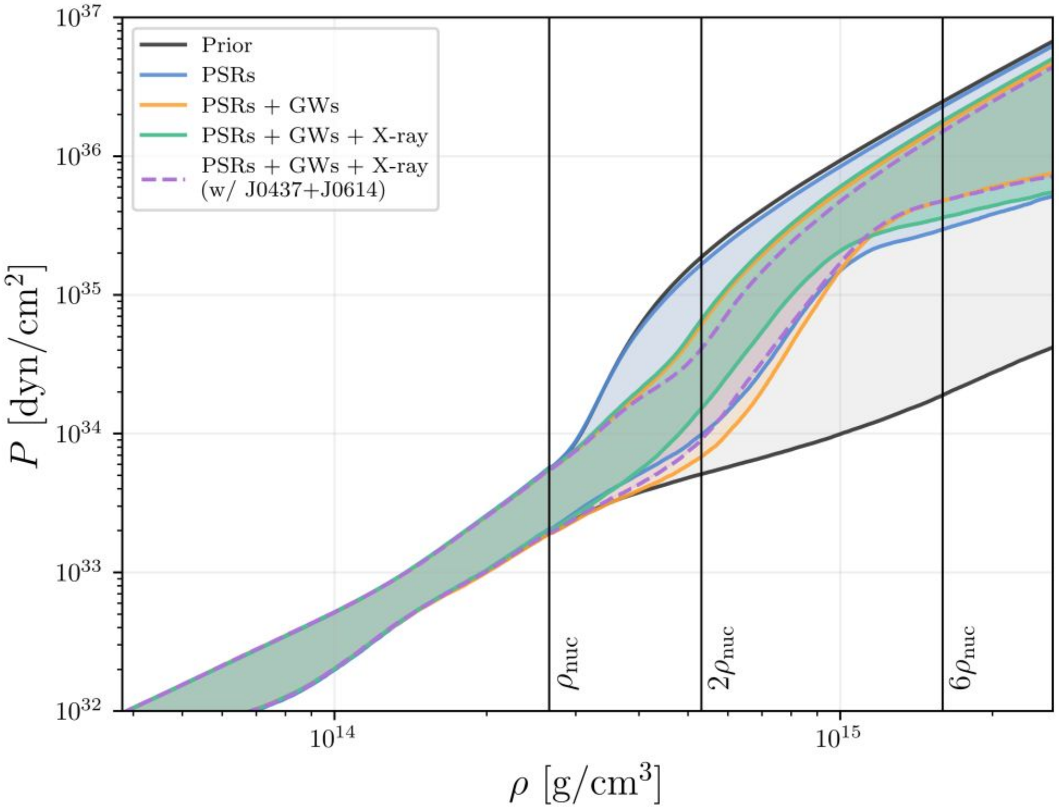
Lami Suleiman, in collaboration with
Anthea Fantina, Francesca Gulminelli, Jocelyn Read
(A&A, arXiv:2512.05315 2026).

CoCoNut Meeting 10/09/2026

Equation of State (EoS) inference from current Neutron Star observations

EoS ↔M, R, Λ





Ng et al 2025 Class. Quantum Grav. 42 205008

From EoS to nuclear parameter inference

Meta-model (MM) approach Phys. Rev. C 97, 025805 (2018)

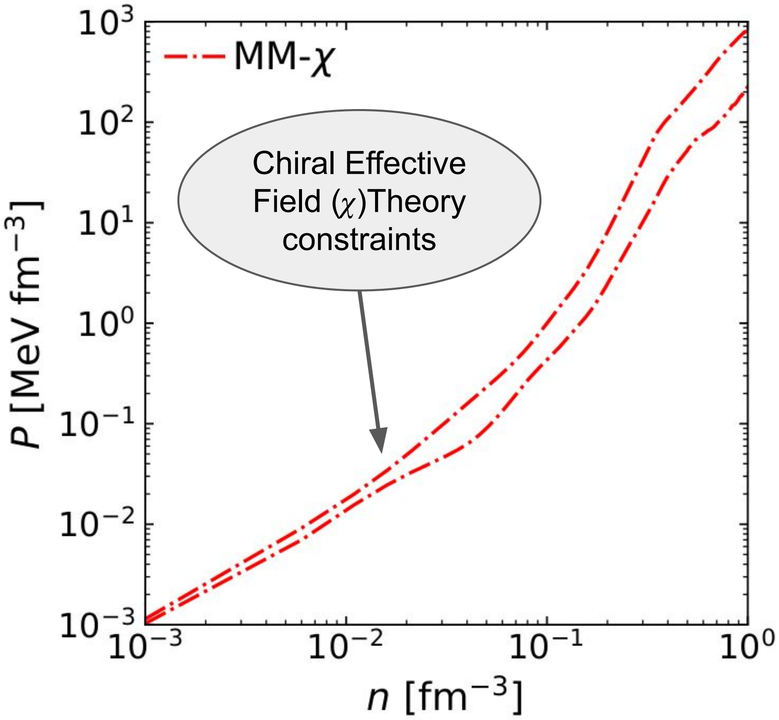
- Equation of state parameterization in terms of nuclear empirical parameters
- Assumption of nucleonic DOF

Parameter X	$X_{\min}$	$X_{\max}$
$n_{\rm sat}$ [fm^{-3}]	0.14	0.17
$E_{\rm sat}$ [MeV]	-17.0	-15.0
$K_{\rm sat}$ [MeV]	190	290
$Q_{\rm sat}$ [MeV]	-1000	1000
$Z_{\rm sat}$ [MeV]	-3000	3000
$E_{\rm sym}$ [MeV]	26	38
$L_{\rm sym}$ [MeV]	10	80
$K_{\rm sym}$ [MeV]	-400	200
$Q_{\rm sym}$ [MeV]	-2000	2000
$Z_{\rm sym}$ [MeV]	-5000	5000
m^*/m	0.6	0.8
$\Delta m^*/m$	0.0	0.2
b	1	10

$$\epsilon_{\rm nuc}(n,\delta) = (m_n n_n + m_p n_p)c^2 + \epsilon^*_{\rm FG}(n,\delta) + \epsilon_{\rm is}(n) + \epsilon_{\rm iv}(n)\delta^2 \ ,$$

$$\epsilon_{\rm is}(n) = \epsilon_{\rm is}(n; n_{\rm sat}, \{X_{\rm is}\}, m^*_{\rm sat}, \Delta m^*_{\rm sat}, b) \ ,$$
$$\epsilon_{\rm iv}(n) = \epsilon_{\rm iv}(n; n_{\rm sat}, \{X_{\rm iv}\}, m^*_{\rm sat}, \Delta m^*_{\rm sat}, b) \ ;$$

$$\{X_{\rm is}\} = \{E_{\rm sat}, K_{\rm sat}, Q_{\rm sat}, Z_{\rm sat}\} \ ,$$
$$\{X_{\rm iv}\} = \{E_{\rm sym}, L_{\rm sym}, K_{\rm sym}, Q_{\rm sym}, Z_{\rm sym}\} \ .$$



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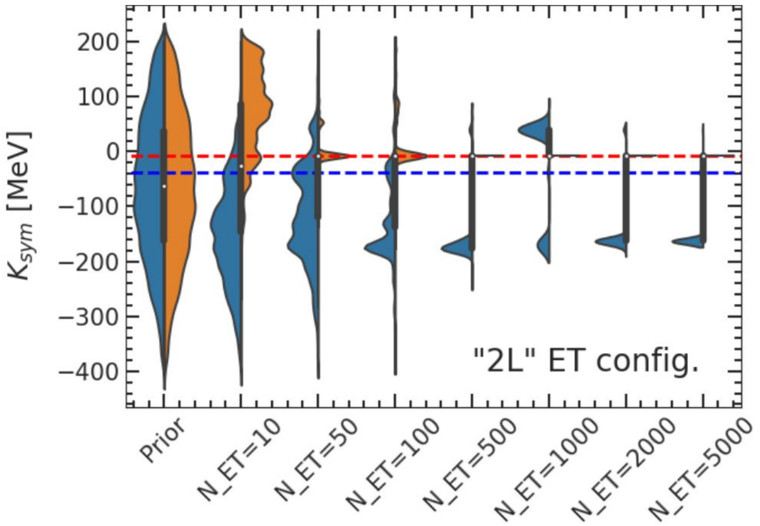
Nuclear parameter inference in the context of Einstein Telescope (Iacovelli et al. 2023)

- Injection study based on simulated population
- Full meta-model constructions

Nuclear physics constraints from binary neutron star mergers in the Einstein Telescope era

Francesco Iacovelli,[1,2] Michele Mancarella,[3,4] Chiranjib Mondal,[5,6] Anna Puecher,[7,8] Tim Dietrich,[9,10] Francesca Gulminelli,[5] Michele Maggiore,[1,2] and Micaela Oertel[11]



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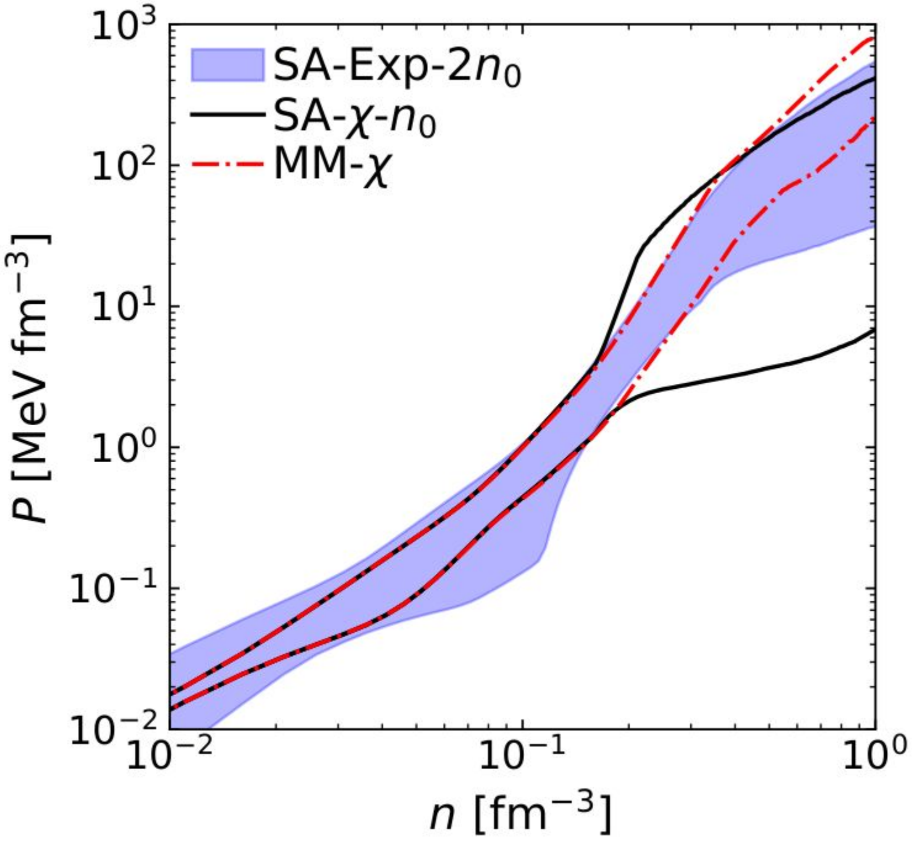
Semi-agnostic constructions **CUTER**

- Meta-model + agnostic (piecewise polytropes or Gaussian Processes)



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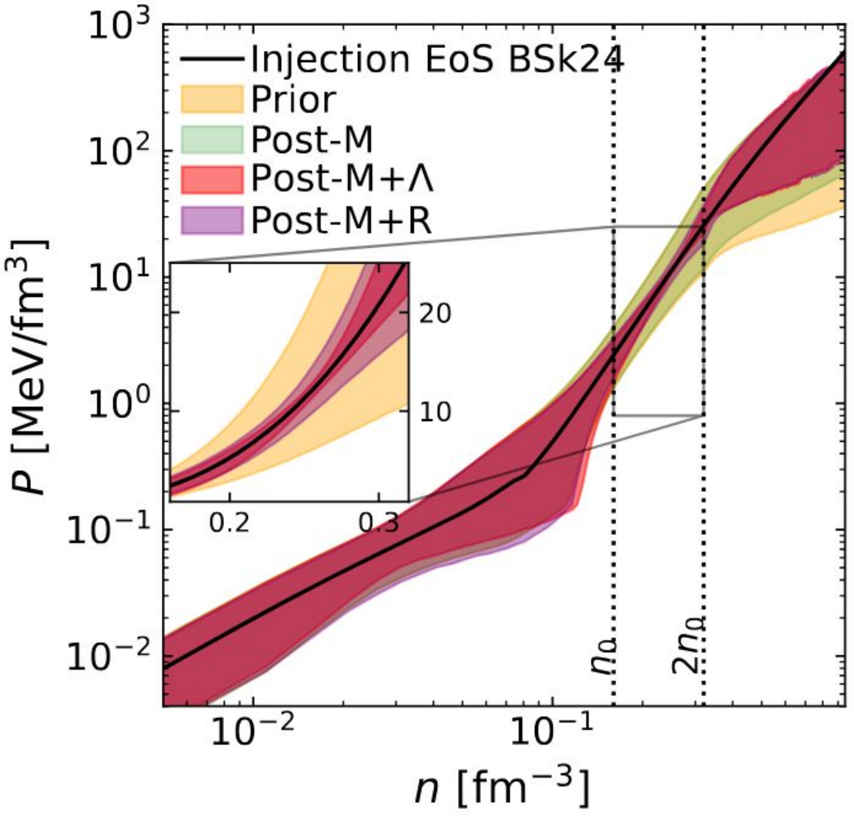

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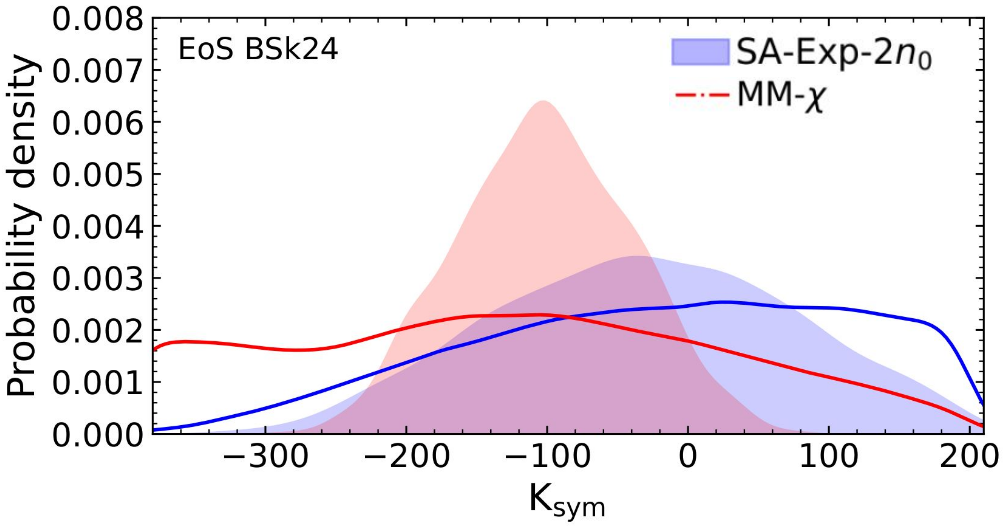

Full MM: very peaked, **off injection**
SA: less peaked but **on injection**
Valid for some NEPs, not all of them
Limited narrowing of the distribution

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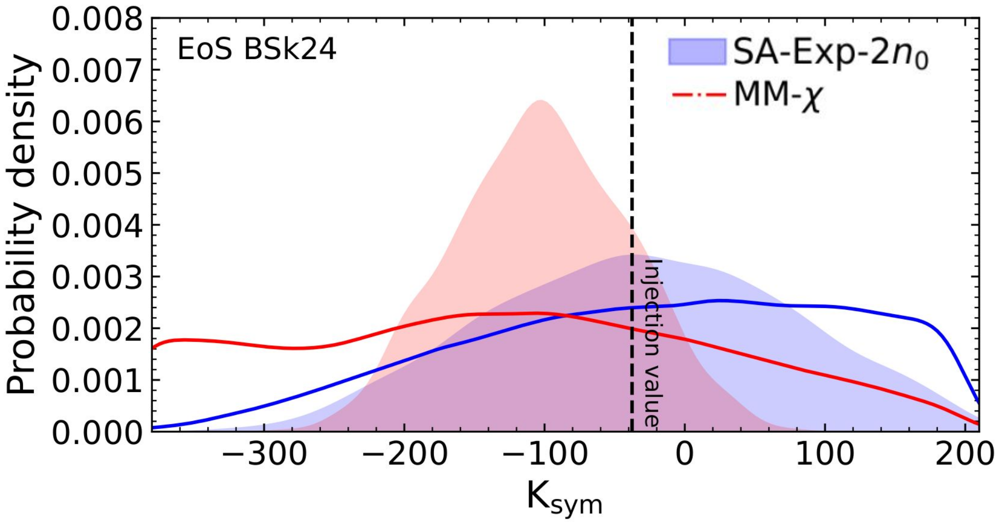

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Conclusion

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- Semi-agnostic models recover the injection value better for some parameters.
- Limited recovery of nuclear parameters despite precise neutron star observations.

Crust **U**nified **T**ool for **E**quation of state **R**econstruction

Inference of neutron-star properties with unified crust-core equations of state for parameter estimation

P. J. Davis[1], H. Dinh Thi[1], A. F. Fantina[2], F. Gulminelli[1], M. Oertel[3], L. Suleiman[3,4,5]

Crust (Unified) Tool for Equation-of-state Reconstruction (CUTER) v2

Philip J. Davis[1†], Hoa Dinh Thi[2†], Anthea F. Fantina[3*†], Francesca Gulminelli[1†], Micaela Oertel[4,5†], Lami Suleiman[6†]

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CUTER (Crust Unified Tool for Equation-of-state Reconstruction)

Davis, Philip John (Project member)[1]; Dinh Thi, Hoa (Project member)[1]; Fantina, Anthea Francesca (Project member)[2]; Gulminelli, Francesca (Project member)[1]; Oertel, Micaela (Project member)[3]; Suleiman, Lami (Project member)[4]

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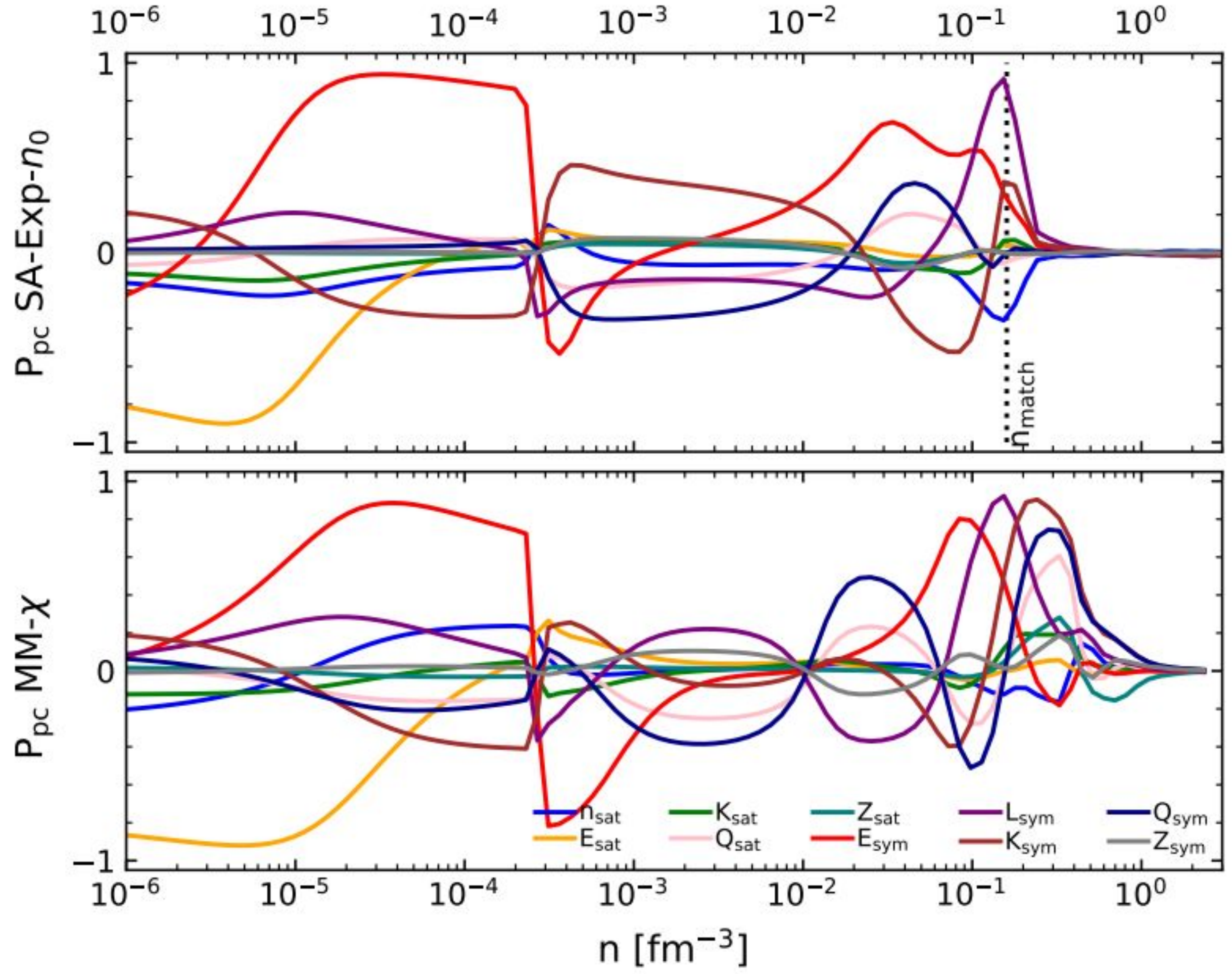
A. **Haber talk: Phys. Rev. C 108, 035803**



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10^{-2}
10^{-1}
10^{0}
P_{pc} SA-Exp-n_0
n_{match}
P_{pc} MM-χ
1
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−1
n_{sat}
E_{sat}
K_{sat}
Q_{sat}
Z_{sat}
E_{sym}
L_{sym}
K_{sym}
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n [fm^{-3}]