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Supervisor Expression of Interest MSCA-IF Marie Sklodowska Curie Action-Individual Fellowship

Supervisor name:	Prof Alberto Guardone
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Department Name: Research topic: (https://www.polimi.it/en/scientific-research/research-structures/departments/)	Department of Aerospace Science and Technology (DAER) PE3_14 Fluid dynamics (physics) PE8_6 Energy systems (production, distribution, application)
MSCA-IF Research Area Panels	☐ CHE_Chemistry ☐ ECO_Economic Sciences X ENG_Information Science and Engineering ☐ ENV_Environmental and Geosciences ☐ LIF_Life Sciences ☐ MAT_Mathematics ☐ PHY_Physics ☐ SOC_Social Sciences and Humanities
Politecnico di Milano Areas:	☐ Cultural Heritage X Smart Cities ☐ Territorial Fragilities ☐ Health ☐ Industry 4.0
Brief description of the Department and Research Group (including URL if applicable):	The interdipartimental laboratory CREALab is investigating fluid mechanics for operating conditions near the Thermodynamic Critical Point (TCP) of liquid-vapour phase transition in complex fluids. This systematic study is required for the design of Organic Rankine Cycles power systems for low temperature energy sources, whereby the thermodynamic conditions are far from the dilute-gas limit. A unique test rig (the Test Rig for Organic VApors) has been designed in the CREALab in order to experimentally characterise the near-TCP non-classical gasdynamics in ORC applications (e.g. expansion shockwaves). Currently, it is the only facility in the world that provides optical access to dense-vapour supersonic flows. An effort is also conducted on the improvement of the capabilities of CFD solvers to accurately capture these flow conditions. The group is currently benefiting from an ERC funding (ERC Consolidator Grant 617603). *Supervisor web page:* *https://www.aero.polimi.it/index.php?id=263&uid=83567&L=0* *Laboratory web page*: https://crealab.polimi.it/

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Brief project description: (max 1 page)	Non-ideal gases can display large drops in the speed of sound for small changes of operating conditions near the TCP. As a consequence, supersonic flows and shock formation are common features of ORC applications operating close to the TCP and needs to be taken into account during the design process. The efforts conducted by the CREALab in the past ten years (especially with the TROVA experiment) have led to a better understanding of the underlying thermodynamic constraints on applications (e.g. ORC expander design), with a focus on steady flow regimes. Recent improvements both in terms of the theory and measurement capabilities make the exploration and characterisation of unsteady properties of non-ideal shockwaves possible. The transformation of a supersonic upstream perturbation of the flow during a shock/perturbation interaction can now be considered (hereafter denoted refraction properties). A recent theoretical work[1] demonstrated that, for conditions relevant to ORC applications, shockwaves near the TCP have thermodynamic properties that considerably change the picture of the refraction problem compared with diluted conditions. As an illustration, in specific conditions for Siloxane D6, an upstream entropy perturbation can be amplified by orders of magnitude larger than in ideal-gas with similar pre- and post-shock states. Other shockwaves have been shown to promote mixing from an incident entropy perturbation with a considerably weaker acoustic emission than in ideal gases. These new kinds of non-ideal properties can therefore be either beneficial or detrimental and should be accounted for in ORC applications. The project proposes to compare the above theoretical findings on non-ideal shock refraction with experimental observations within the TROVA. A two years project is considered. Two main objectives are expected: • **Conduct an experimental campaign on shock/perturbation interaction**. A small perturbation is injected in the upstream flow (several possibilities may be considered: injection of fluid with slightly different thermodynamic state, LASER energy deposit or by a bluff body) and convected into a steady shockwave (either oblique or normal). The recent developments in measurement capabilities (control of thermal stability, LDV measurements, numerical Schlieren) are crucial points for the success of this part of the project. Relevant operating conditions can already be assessed from the existing theory. • **Extend the existing theory to general upstream perturbations** (in terms of shape and all three hydrodynamic eigenmodes) **and to oblique shockwaves** to improve its flexibility regarding the comparison with the experiment. Compare the results with both numerical simulations (with existing CFD capability) and the experimental campaign. The main outcome of the project is a validation of the theory and, if proven correct, a new way of benefiting from the non-ideal shockwaves behaviour in industrial applications may be demonstrated.

	[1] Alferez, N., & Touber, E. (2017). *Journal of Fluid Mechanics, 814*