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An implicit-explicit lagrange projection splitting scheme with capillarity effects and wetting

L. Tallois[1]*, S. Peluchon[2] and P. Villedieu[3]

[1] CEA-CESTA, 15 avenue des Sablières, 33114 Le Barp, France, lucas.tallois@cea.fr
[2] CEA-CESTA, 15 avenue des Sablières, 33114 Le Barp, France, simon.peluchon@cea.fr
[3] INSA Toulouse, 135 Av. de Rangueil, 31400 Toulouse, France,
phillipe.villedieu@insa-toulouse.fr

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During re-entry into the atmosphere of a planet, a spacecraft such as a probe, for example, undergoes significant heating due to the friction of atmospheric gases. In order to guarantee the integrity of the structure, the face of the capsule that undergoes braking is covered with a heat shield. During the atmospheric re-entry phase, the surface of this thermal shield will undergo a physico-chemical degradation globally called ablation. The melting of the metallic part as well as the sublimation of the carbon structure give rise to complex two-phase flows.

In this work, a diffuse interface method is considered. The advantages of such method are numerous: the same equations are solved in the whole domain, interfaces do not require any specific treatment and appearance of new interfaces as well as the changes of topology are done naturally. In the case where one wishes to model the two-phase flow between a gaseous phase and a liquid phase, where the second phase is not present initially and appears from the solid melting, these methods seem the most relevant. In particular, we will use the five-equation model [1, 2].

The capillarity effects are taken in account with the CSS formulation [3]. The system is solved with the implicit–explicit acoustic-transport splitting scheme introduced in [4, 5], where the surface tension terms are solved implicitly. A contact angle boundary condition designed for unstructured mesh is used to accurately take into account wetting phenomena. Several two-dimensional test cases are presented to validate the method.

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