
Operator PROJ_CHAMP

1 Goal

The goal of the operator is to project the fields of a structure of data result on another grid. This order can be used for example to transfer on a “mechanical” grid, the result of a thermal calculation carried out on a “thermal” grid different.

One can also “continue” a thermal calculation (or mechanics) on another grid (more or less refined).

The order also makes it possible to define “zones” (geometrical) which one projects the ones on the others what makes it possible to solve the problem of a desired discontinuity of the field project (for example along the lips of a crack).

For reasons of performances CPU, one can initially calculate the geometrical pairing of the two grids and store the structure of data produced in a concept which one will be able to re-use later to carry out projections of the fields.

It is possible to project an “isolated” field or a set of fields resulting from one SD_RESULTAT.

Product a structure of data SD_RESULTAT or an “isolated” field or a structure of data CORRESP_2_MAILLA.

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Code_Aster

Version
default

Titre : Opérateur PROJ_CHAMP
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Date : 18/04/2018 Page : 3/16
Clé : U4.72.05 Révision :
945fe782e0b5

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2 Syntax

```
resu = PROJ_CHAMP (  
  # Determine if the projection of the fields will be carried out  
  ◊ PROJECTION = ['YES', 'NON'] [DEFECT]  
  
  # Allows to provide a correspondence between two grids calculated  
  beforehand  
  ◊ MATR_PROJECTION = matproj, [corresp_2_mailla]  
  
  # Choice of the method of projection  
  ◊ METHOD = ['CAR'|'COLLOCATION'|'ECLA_PG'|'NUAGE_DEG_0'|  
            'NUAGE_DEG_1'|'COUPLAGE'|'SOUS_POINT'] [DEFECT]  
  
  # Information of both grids or models for projection  
  # Modè or grid of reference:  
  ◆ / MODELE_1 = mo1, [model]  
    / MAILLAGE_1 = ma1, / [grid]  
                                / [skeleton]  
  
# MODè or grid on which one wishes to project:  
  ◆ / MODELE_2 = mo2, [model]  
    / MAILLAGE_2 = ma1, [grid]  
  
# What wants one to project: an isolated field or one SD_RESULTAT ?  
  ◆ / CHAM_GD = champ1 / [cham_gd_sdaster  
    / RESULT = evol1, / [evol_ther]  
                                / [evol_elas]  
                                / [evol_noli]  
                                / [evol_char]  
                                / [dyna_harmo]  
                                / [dyna_trans]  
                                / [mode_meca]  
                                / [mode_stat_depl]  
                                / [base_modale]  
                                /...  
  
# Mots key additional for the methods:  
#                               'COLLOCATION', 'ECLA_PG', 'CAR'  
  ◊ CAS_FIGURE = ['3D'|'2D'|'2.5D'|'1.5D'],  
  # To transform the geometry of the nodes of the grids  
  ◊ TRANSF_GEOM_1 = (fx, fy, [fz]) [function]  
  ◊ TRANSF_GEOM_2 = (fx, fy, [fz]) [function]  
  ◊ DISTANCE_MAX = d_max, [R]  
  ◊ DISTANCE_ALARME = d_ala, [R]  
  ◊ ALARM = ['YES', 'NOT'], [DEFECT]  
  ◊ PROL_ZERO = ['YES', 'NOT'] [DEFECT]  
  ◊ TYPE_CHAM = 'NOEU'  
  
# Keyword additional for the methods 'NUAGE_DEG_0/1'  
  ◊ CHAM_NO_REFE = chno2, [cham_no]  
  
# Keyword additional for method 'SOUS_POINT'  
  ◊ ◆ CARA_ELEM = carac, [cara_elem]  
  
  # To transform the geometry of the nodes of the grids  
  ◊ TRANSF_GEOM_1 = (fx, fy, [fz]) [function]  
  ◊ TRANSF_GEOM_2 = (fx, fy, [fz]) [function]  
  
# Projette fields of a sd_resultat  
  # Selection of the fields
```

```

    ◇ / TOUT_CHAM = 'YES', [DEFECT]
      / NOM_CHAM = l_noch, [l_Kn]
    # Selection of the sequence numbers
    ◇ / TOUT_ORDRE = 'YES', [DEFECT]
      / NUME_ORDRE = l_nuor, [l_I]
      / INST = l_inst, [l_R]
      / FREQ = l_freq, [l_R]
      /LISTE_INST = l_inst, [listr8]
      /LISTE_FREQ = l_freq, [listr8]
    ◇ / CRITERION = 'RELATIVE', [DEFECT]
      P RECISION = / 1.0E-6 , [ DEFECT ]
      / prec, [R]
      / CRITERION = 'ABSOLUTE',
      PRECISION = prec,
    # Imposer the classification of the cham_no (modes)
    ◇ NUME_DDL = naked [nume_ddl_sdaster]

# Withppariement "by zones" (prohibited if METHODE=' ECLA_PG')
◇ VIS_A_VIS = _F (
  ◆ | TOUT_1 = 'YES',
    | GROUP_MA_1 = lgma1, [l_gr_maille]
    | GROUP_NO_1 = lgnol, [l_gr_noeud]

  ◆ | TOUT_2 = 'YES',
    | GROUP_MA_2 = lgma2, [l_gr_maille]
    | GROUP_NO_2 = lgnol, [l_gr_noeud]

  # if method 'COLLOCATION'
  ◇ CAS_FIGURE = ['3D'|' 2D'|'2.5D'|'1.5D'],
  ◇ TRANSF_GEOM_1 = (fx, fy, [fz]) [function]
  ◇ TRANSF_GEOM_2 = (fx, fy, [fz]) [function]
),

◇ NOM_PARA = will lpara, [l_Kn]
◇ TITLE = titr, [l_Kn]
◇ INFORMATION = / 1, [defect]
      / 2,
);
```

Type of the result of the operator:

- if the keyword is used PROJECTION=' NON', resu is a "matrix of projection" (standard corresp_2_mailla),
- if the keyword is used CHAM_GD, resu is a field of comparable nature that champ1,
- if the keyword is used RESULT, resu is one SD_RESULTAT of the same type than evol.

3 Operands

3.1 Operands PROJECTION and MATR_PROJECTION

The operator can be used of three different manners according to the uses of the keywords PROJECTION and MATR_PROJECTION. These three modes of use are described hereafter.

3.1.1 Calculation “at a stretch”

It is the by default mode. One calculates a geometrical correspondence initially (called matrix of projection), then one uses this matrix to project the fields to be projected (PROJECTION=' OUI '). The matrix of projection is lost at the end of the operator.

3.1.2 Calculation of the matrix of projection

The geometrical correspondence is calculated and one stops (PROJECTION=' NON '). The matrix of projection is the concept result of the order.

Note: this kind of calculation is currently possible only with the methods 'COLLOCATION' or 'COUPLING'.

3.1.3 Use of a matrix of projection

One uses the matrix calculated previously to project the fields (keyword MATR_PROJECTION).

Note: SI one wants to project fields PaR element, it is necessary to use the keyword MODELE_2.

3.1.4 Examples

To do a calculation “at a stretch”, one writes for example:

```
TEMP2=PROJ_CHAMP (RESULTAT=TEMP1, METHODE=' COLLOCATION',  
                 MAILLAGE_1=MA1, MAILLAGE_2=MA2, NOM_CHAM=' TEMP')
```

To do a calculation in two times, one writes:

```
MATPROJ=PROJ_CHAMP (METHODE=' COLLOCATION', PROJECTION=' NON',  
                   MAILLAGE_1=MA1, MAILLAGE_2=MA2,)
```

```
TEMP2=PROJ_CHAMP (RESULTAT=TEMP1, MATR_PROJECTION=MATPROJ,  
                 NOM_CHAM=' TEMP')
```

3.2 Operand METHOD

There exist five methods of projection.

Methods 'COLLOCATION' and 'NUAGE_DEG_0/1' are adapted to the projection of the fields to **nodes**. Method 'COLLOCATION' is to be used in priority: C' is most robust and she does not extrapolate the values of the initial field. Two methods 'NUAGE_DEG_0/1' can be used if one cannot make differently. For example, when the initial grid does not contain meshes, but only nodes (a grid containing the positions of transmitters).

Notice on the method collocation:

For the projection of fields 'NOEU' or 'ELNO', there exists an alternative to PROJ_CHAMP for certain particular configurations of projection, in particular met in THM for the postprocessing of the pressure. If the user wishes to project a result of a quadratic grid on the same linearized grid, it can use:

```
MACR_ADAP_MAIL (  
    ADAPTATION=' MODIFICATION', DEGRE=' OUI', MAJ_CHAM=_F (...),)
```

who can prove sometimes faster on the large studies.

Method 'ECLA_PG' is adapted to the fields at the points of Gauss (ELGA). It functions only on one field "isolated" (keyword CHAM_GD).

Another method, named 'COUPLING' was introduced for calculations of interaction fluid-structure when Code_Aster is coupled with the code of mechanics of the fluids Code_Saturn. This method is comparable to collocation.

A named method 'SOUS_POINT', is used to build fields (variable of orders of the type TEMP, HYDR, NEUT or of constraints of the type SIEF_R), on mechanical models under-points starting from a field or of a result resulting from a calculation on a model 3D.

Method 'CAR' allows to choose the method most recommended according to the type of the field: 'ECLA_PG' for a field 'ELGA', and 'COLLOCATION' for the other fields.

Unfortunately, like the method 'ECLA_PG' is authorized only on one isolated field, it is not possible to print with the method 'CAR' all fields of a structure of data.

3.2.1 Méthode= 'COLLOCATION'

First method (COLLOCATION) is classical: to calculate the value on a node ($N2$) grid $ma2$, one seeks in which element of the grid $ma1$ this node is, then one interpolates the value using the functions of form of this element.

When the node is not geometrically inside one of the elements of $ma1$ (i.e., apart from the modelled geometrical field), the method connects the node and the point of the element nearest and interpolates the value using the functions of form of this element. There is thus (by default) a "prolongation" of the field outside the initial grid. The operand DISTANCE_MAX allows to modify this behavior.

Problem posed by the "mixed" fields:

If components carried by the various nodes of element of $ma1$ are not all the same ones, for example, if the nodes tops do not carry the same components that the nodes mediums, one cannot use "stupidly" the interpolation by the functions of form of the element.

The calculation of the value of a component on the node $N2$ is made in the following way:

- Geometrical stage (made independently of the fields project):
The element is determined $ima1$ associated with $N2$, then one calculates, with the functions of form of this element, the coefficients weighting for **all** nodes of $ima1$. The sum of these coefficients is worth 1.
- Stage of projection of a component of a field:
 - If all nodes of $ima1$ carry this component, it does not have there problems, one applies the formula of weighting selected.
 - If the component is not carried by **all** nodes of $ima1$:
 - So certain nodes carrying the component have a "weight" > 0 , one makes use of those by modifying the formula of weighting so that the sum of the coefficients selected makes 1.
 - If none the nodes carrying the component has a weight > 0 , one is satisfied to make an arithmetic mean of the components present on $ima1$.

3.2.2 Méthode= 'NUAGE_DEG_1/0'

The second family of methods (NUAGE_DEG_1/0) (**strongly disadvised**) use the concept of groups of dots, by forgetting the finite elements present in the models. It is more general than the method 'COLLOCATION' because it makes it possible to project a field with the nodes without these nodes being carried by finite elements (for example a set of sensors). On the other hand, this method often disturbs the users familiar of the finite element method, because it is purely geometrical and does not see the material borders nor the holes: the computed value on a node of the new grid depends on **all** the nodes which are close for him. In the zones of strong gradient, the values can be obtained with a strong extrapolation, which is seldom "physical".

The idea of these methods is to make pass “as well as possible” a hyperplane of degree 1 or 0 (`NUAGE_DEG_1/0`) among the points of grid 1. The weight of the points is very strongly dependent on their distance to the node `N2` : the weight decrease like exponential decreasing distance. Once coefficients of the hyperplane calculated (for a node `N2`), one evaluates this hyperplane with the coordinates of the node `N2` .

3.2.3 Méthode= ‘ECLA_PG’

Third method (`ECLA_PG`) allows to project fields known at the points of Gauss of the grid (also called points of integration). For example, it is possible to project stress fields, deformations or variables internal.

This method uses the programming of the order `MACR_ECLA_PG` and of the method of ‘COLLOCATION’ described previously. Each mesh of the initial grid is burst in as many under-meshes as of points of Gauss contained in the mesh, in the same manner as the current bursting of `MACR_ECLA_PG`. In the second time, the matrix of projection of the method is used ‘COLLOCATION’ between the points of Gauss of the second grid and the meshes previously burst.

This method is prohibited with the keyword `VIS_A_VIS` .

Remarks concerning the pyramidal elements at 27 points of Gauss:

- On the 27 points of Gauss of this diagram of integration, 12 are located in “outside” of the pyramid. Their values are ignored during projection, because one does not wish only one pyramidal element of the grid “1” influences elements of the grid “2” which do not have a geometrical intersection with him; it would be the case of an element close to the border between 2 different materials which could influence the elements located on other side of the border.
- On the 15 points of Gauss located inside, one preserves only 8 points because one did not know “to cut out” a pyramid in 15 subelements of simple form. On the whole, for a pyramid of the grid “1”, only 8 points of Gauss will be used during projection.
- For a pyramid of the grid “2”, it is necessary to give a value to the 27 points of Gauss. So that the 12 external points are affected by an “interior” value, one carries out a homothety to bring back them inside the pyramid.
- The projection of the pyramids at 27 points of Gauss is thus very “debatable”. The only guarantee is that the value of the field after projection is well that of a point of Gauss of the field “origin” (without interpolation nor extrapolation) and that the recopied point is a point geometrically close to the “target” point of Gauss. This development was carried out to allow the projection of fields `ELGA` on complex models (formed by various types of elements) by hoping that the pyramids are very few (some zones of connection).

3.2.4 Méthode= ‘COUPLING’

Fourth method (`COUPLING`) is an alternative very close to the collocation and specifically introduced for the coupling with the code of mechanics of the fluids Saturn (in finished volumes). It is employed in the macro-order `CALC_IFS_DNL` who allows this coupling `YEWS`.

It is available only to generate the structure of data `CORRESP_2_MAILLA` (case `PROJECTION='NON'`). It makes it possible to project fields with the nodes between a grid with the finite elements (structure) and grids coming from the code to finished volumes *Code_Saturne*. These grids, imported in *Code_Aster*, are composed of specific elements, because there are no functions of forms associated.

3.2.5 Méthode= ‘SOUS_POINT’

This method is based on the method of ‘COLLOCATION’ and is similar to the method `ECLA_PG` by removing the stage of bursting of the grid. The inlet limits are `cham_no` or of `CHAM_ELEM/ELNO` in the form of field isolated or contents in a result from type `EVOL_THER`. The first stage consists in building a grid starting from the coordinates of the under-points of `MODELE_2` (mechanical model) for all the points of the families of the list `MATER` (for fields of type `TEMP`, `HYDR`, `NEUT`) and for all the points of the family `RIGI` (for the fields of the type `SIEF_R`).

The inlet limits are then projected on this grid by a method of 'COLLOCATION' (by forcing the type of fields created with `cham_no`). Finally the values obtained for each point are recopied in one CHAM_ELEM/ELGA, on the corresponding points and under-points (see V1.01.318, V1.01.365).

This method is prohibited with the keyword `VIS_A_VIS` and with `PROJECTION = 'NOT'`.

Notice n°1 :

The projection of the fields of the type `SIEF_R`, their initial reference mark does not modify. Method `SOUS_POINT` applied to this kind of field a stress field resulting from a calculation on finite elements 3D makes it possible to project on elements of hull under-points or multi-layer. A stress field of the type `SIEF_R` on elements of hulls must be expressed in the local reference mark of the elements. **One thus should not use this field project without him to change reference mark**. The order `MODI_REPERE` allows to make this operation. For the fields of the type `TEMP`, `HYDR` and `NEUT` who are scalar fields independent of the reference mark, `Re` preceding mark does not apply.

Notice n°2:

The current version of `Salomé_Meca` cannot visualize the fields under-points. However, in the phase of checking, it is perhaps useful to check the good agreement of the grids. For that, it is possible at the time of the phase of projection to obtain a grid of `POI1` correspondent at all the under-points. The checking of the good agreement can then be realized in the module `PARAVIS` or `SMESH` by superimposing the voluminal grid 3D and the grid of `POI1`. This grid is saved with the format `MED` in the repertoire "repe_out", it is thus necessary to indicate this repertoire in the profile of study and to use the key word `INFO=2`.

3.3 Keyword `VIS_A_VIS`

This keyword optional factor makes it possible to project the field "per pieces". By default, it is **the unit** field which is project.

This keyword makes it possible to project discontinuous fields or to solve the problem of the projection of complex models (see § [3.3.4]) or to improve performances CPU of heterogeneous projections of model (see § [3.3.5]).

If it is used this keyword makes it possible to the user to project a field (with the nodes) a priori discontinuous (on a line or a surface) and to preserve this discontinuity for the field project:

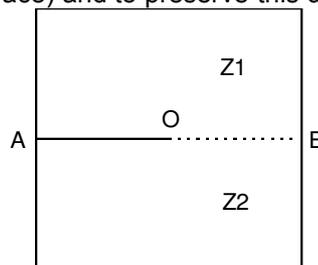


Figure 3.3-a: fissured structure.

For example, that is to say the fissured structure of the figure [3.3-a]. The field of displacement is discontinuous on the crack: the upper lip and the lower lip although geometrically confused have each one their own field of displacement.

Let us suppose that one has 2 grids (M and M') different from this structure and that for each one of these grids, zones $Z1$ and $Z2$ are represented by two `GROUP_MA` named $Z1$ and $Z2$.

One will be able to write:

```
VIS_A_VIS = ( _F (GROUP_MA_1 = 'Z1', GROUP_MA_2 = 'Z1'),
              _F (GROUP_MA_1 = 'Z2', GROUP_MA_2 = 'Z2')) ,
```

Values of the field project on the upper lip (pertaining to $Z1$) account only values of the initial field will take on $Z1$. In the same way the values obtained on the lower lip depend only on the initial field on $Z2$.

Notice on the use of `VIS_A_VIS` + field `ELNO` :

One could believe that the use of the keyword `VIS_A_VIS` allows to project a field `ELNO` by preserving a discontinuity on the interface between two zones. It is nothing as one explains it to the § [3.13.2].

3.3.1 Operands `TOUT_1 / GROUP_MA_1 / GROUP_NO_1`

These operands are used to define the whole of the meshes (`'COLLOCATION'`, `'ECLA_PG'`,) or of the nodes (`'NUAGE_DEG_1/0'`) to take into account in the initial grid.

3.3.2 Operands `TOUT_2 / GROUP_MA_2 / GROUP_NO_2`

These operands are used to define the whole of the nodes or the elements where one evaluates to it (S) field (S).

The use of `TOUT_2` or of `GROUP_MA_2` activate a checking of homogeneity of the meshes before construction list of the corresponding nodes. For example, if there exists at least a mesh `3D` among the meshes well informedES then meshes `2D`, `1D` and `0D` will be ignored and the subjacent nodes will not be part of the list of the nodes if they did not belong not at the same time with a mesh `3D`. The same thing occurs as soon as there is a mesh `2D` (and in the absence of mesh `3D`) with the meshes `1D` and `0D`. On the other hand meshes `0D` are not ignored when one or more meshes `1D` are present (and in the absence of meshes `2D` and `3D`).

3.3.3 PrecisionS on covering

When a node to be projected is present in several occurrences of `VIS_A_VIS`, it is the projection of this node determined in the last occurrence which is preserved.

The only exception to that occurs when projection is considered to be distant. In this case, if the node concerned were already treated by a preceding occurrence, one preserves projection previously calculated.

3.3.4 Use of the keyword `VIS_A_VIS` to project the complex models

The keyword `VIS_A_VIS` allows for example to solve the problem of the projection of a field of temperature calculated on a model containing of the elements 3D and the elements of hull (a solid whose skin interns would be covered with a "liner" with a grid in elements of hull).

The problem is the following: the elements 3D carry on their nodes the only degree of freedom `TEMP`, whereas the elements of hull (thermal) carry the 3 degree of freedom: `TEMP_MIL`, `TEMP_INF` and `TEMP_SUP`. If one does not take precautions and that one projects all the model at a stretch, the degree of freedom `TEMP_MIL`, `TEMP_INF` and `TEMP_SUP` "will be lost" during projection. Indeed, as the initial grid contains voluminal elements, it is the procedure "3D" which is applied: for each node of grid 2, one seeks a voluminal mesh which contains this node (or which of it is close). Once this found mesh, one interpolates the degrees of freedom carried by **all** nodes of this mesh. Practically, no mesh 3D can carry on all its nodes the degrees of freedom `TEMP_MIL`, `TEMP_INF` and `TEMP_SUP`; those are thus lost.

To solve this problem it is necessary to do something like:

```
evo2= PROJ_CHAMP (RESULTAT=evol,  
  VIS_A_VIS = ( _F (GROUP_MA_1: 'VOLU' , GROUP_MA_2=' VOLU',),  
              _F (GROUP_MA_1: 'LINER', GROUP_MA_2=' LINER',),)
```

In this manner, meshes of `'LINER'` grid 2 will be affected by the values carried by the meshes of `'LINER'` grid 1 and they will carry the same degrees of freedom.

3.3.5 Use of `VIS_A_VIS` for the heterogeneous grids

The projection of heterogeneous grids (presence of small meshes and large meshes) can largely degrade performances CPU of the operator.

For reasons of performance, the elements of the grid are put in of the same "boxes" cuts (a regular Cartesian grid). During projection, one does not test whereas the elements of the box which contains

the point to be projected. If the grid is very heterogeneous, certain boxes are empty and others contain many elements, which causes a degradation of the performances.

In this case, the use of `VIS_A_VIS` can improve the performances considerably. For that, it is enough to create a group satisfying the fine meshes and the another coarse meshes.

3.4 Operands `MODELE_1`, `MAILLAGE_1`

```
/ MODELE_1 = mo1,  
/ MAILLAGE_1 = ma1,
```

These two keywords make it possible to specify the initial grid (or skeleton in the case of the under-structuring). Projection goes from the grid "1" towards the grid "2".

This grid is that which is associated with the fields to project (`evol1` or `champ1`).

Note: it is preferable to use the keyword `MODELE_1`, because that makes it possible to limit the meshes candidates to projection (if the model is more restricted than the grid).

3.5 Operands `MODELE_2`, `MAILLAGE_2`

```
/ MODELE_2 = mo2,  
/ MAILLAGE_2 = ma2,
```

These two keywords make it possible to specify the final grid. It is the grid on which will be created the projected fields.

Notice important:

There still, it is preferable to use the keyword `MODELE_2`, even if finite elements of `MODELE_2` are not used. One makes use only of the coordinates of the nodes of the grid (`ma2`) associated with `mo2` . The fact of using the name of the model (`mo2`) rather than the name of the grid (`ma2`) allows to avoid certain nodes of construction (located very far) which sometimes strongly deteriorate performances (CPU) of projection.

3.6 Operand `RESULT`

```
RESULT = evol1,  
Name of the concept result which one wants to project.
```

Note:

For one `evol_noli` , the concept `Dsultat` will not contain (by default) only the fields `DE` displacements. To calculate the internal variable and stress fields correspondents, it is preferable to use the order `STAT_NON_LINE` by using the keyword `PREDICTION: 'DEPL_CALCULE'` .

3.7 Operand `CHAM_GD`

This keyword is used to indicate the field to be projected (when one is not projected `sd_resultat`).

For the methods 'NUAGE_DEG_1/2' the field must be one `cham_no`.

For the method 'ECLA_PG', the field must be one `cham_elem/ELGA`

3.8 Operand `CHAM_NO_REFE`

For the methods 'NUAGE_DEG_1/2' the field provided behind `CHAM_NO_REFE` is one `cham_no` "model" for the fields with the nodes to be created during projection. This keyword is obligatory.

When one projects a field "isolated" (for example from `TEMP_R`), one should be provided `cham_no` same size (`TEMP_R`).

When one projects the fields of one `sd_resultat`, since the keyword `CHAM_NO_REFE` has only one value, one sees that one will not be able (in general) to project several `NOM_CHAM` different

3.9 Operand `CAS_FIGURE`

This keyword (optional) is used to direct the method 'COLLOCATION' towards L' one of the 4 following cases:

- "3D" The only elements of the grid "1" which will be used for projection are the voluminal elements: hexahedrons, pentahedrons, tetrahedrons and pyramids. The nodes have 3 cordonnées (X, Y, Z) .
- "2D" The only elements of the grid "1" which will be used for projection are the surface elements: quadrangles and triangles. The grid is supposed plan. The nodes have 2 cordonnées (X, Y) .
- "2.5D" The only elements of the grid "1" which will be used for projection are the surface elements: quadrangles and triangles. The grid is 3D. The nodes have 3 cordonnées (X, Y, Z) . It is the case of the "hulls" plunged in 3D.
- "1.5D" The only elements of the grid "1" which will be used for projection are the linear elements: segments. The grid can be 2D or 3D. The nodes have 2 or 3 cordonnées $(X, Y, (Z))$.

This keyword can also be used under the keyword `VIS_A_VIS`. It can change value according to the occurrences.

If the user does not inform this keyword, the program traverses the list of the meshes of model 1, candidates with being projected (this list can be filtered thanks to the keyword `VIS_A_VIS`).

```
if there exists at least 1 mesh 3D in this list      => CAS_FIGURE=' 3D'  
if not:  
  if there exists at least 1 mesh 2D in this list  
    if the geometry is '2D'                        => CAS_FIGURE=' 2D'  
    if the geometry is '3D'                        => CAS_FIGURE=' 2.5D'  
  if not:  
    if there exists at least 1 mesh 1D in this list => CAS_FIGURE=' 1.5D'
```

3.10 Operands `TRANSF_GEOM_1` and `TRANSF_GEOM_2`

2 keywords `TRANSF_GEOM_1/2 = (fx, fy, [fz])` allow to carry out one (or two) geometrical transformations on cordonnées of the nodes grids 1 and 2 frontant to make projection. This geometrical transformation is temporary (the time of the phase of pairing): the grids are not modified

In 2D for example, 2 functions (or formulas) fx, fy are functions of (X, Y) who will be applied to calculate the 2 new coordinates of the nodes: fx to calculate the new one X and fy to calculate the new one Y .

The applications aimed by these keywords are for example:

- Projection of a grid (given in mm) on another grid (given in m). The geometrical transformation (`TRANSF_GEOM_2`) is a homothety of report 1000.
- Projection of a thermal calculation done on an axisymmetric model 2D on a model 3D (but axisymmetric!). The geometrical transformation (`TRANSF_GEOM_2`) is then that which "crushes" the solid 3D in a meridian half-plane:

Let us suppose that the grid 3D is a solid of axis Oz , functions fx, fy, fz to provide are:

$$fx = \sqrt{(x^2 + y^2)} \quad fy = z \quad fz = 0.$$

An example of use keyword `TRANSF_GEOM_2` is given in the case test `zzzz110a`

In general, `TRANSF_GEOM_2` is sufficient, but it can be convenient to combine the two transformations to pass by a simpler intermediate geometry. If for example, one wants to project a result calculated on an air cooler of geometry (A) towards another slightly different geometry (B), it can be simpler to break up the geometrical transformation via an intermediate cylinder.

Note:

In the phase of checking, it is perhaps useful to check the good agreement of the grids. For that, it is possible at the time of the phase of projection to obtain the grids after geometrical transformation. The checking of the good agreement can then be realized in the module `PARAVIS` or `SMESH` of `Salome_Meca` by superimposing the grids.

These grids are saved with the format MED in the repertoire "repe_out", it is thus necessary to indicate this repertoire in the profile of study and to use the key word INFO=2 .

3.11 Operand CARA_ELEM

This operand is obligatory for the method SOUS_POINT and prohibited for the others. It makes it possible to inform the object CARA_ELEM bound to MODELE_2 in order to take into account all the related information at the under-points and necessary to projection.

3.12 Selection of the names of the fields

Keywords TOUT_CHAMP = 'YES' or NOM_CHAM = l_noch allow to choose which are the fields of SD RESULT that one wants to project (by default all fields with the nodes). One can also project the fields by elements "ELNO"and"ELEM", for that it is explicitly necessary to give their names via the keyword NOM_CHAM.

3.13 Remarks on the projection of the fields by elements for the method 'COLLOCATION'

This possibility was introduced initially to make it possible to project the fields of pressure calculated by the Code Saturn (constant by elements) on the skin of a mechanical grid Aster. This development being general, it is available for all the fields "ELEM"and"ELNO"but the result of projection is sometimes a little diverting.

As for the fields with the nodes, the fields by projected elements of the concept ev01 in the concept resu the same names will carry (for example: 'SIGM_ELNO').

Projected fields (resu) will be "natural" by default in the same way as the fields "origin" (ev01): "ELEM"or"ELNO".

One can however modify this behavior by default by using the keyword TYPE_CHAM=' NOEU' to force the fields projected to be fields with the nodes.

What does one make numerically?

- Fields of the type ELNO : for each mesh of grid 2, one traverses the nodes of this mesh and one calculates the value of each node as one would do it for a field with the nodes. The result of this projection is thus (by construction), a field ELNO who is **continuous** between the elements whereas the initial field is not it.
- So moreover, grids 1 and 2 have common nodes (for example, the projection of a quadratic grid on a linear grid), then the value projected on a node (N2) grid 2 has an unforeseeable side: the value carried by the node N2 will be that carried by the equivalent node of grid 1 **in one of the meshes** sharing this node. But the choice of this mesh is arbitrary. Fields of the type ELEM (constant by mesh): the value carried by a mesh of grid 2 is obtained by arithmetic mean of the values carried by its nodes (calculated as for a field ELNO).

When one does not use TYPE_CHAM=' NOEU', the projection of fields by elements has direction only if the elements projected the ones on the others are in the same way "standard" (hull, beam, isoparametric). Indeed, if one projected for example a field 3D of 'SIGM_ELNO' about a formed linear model by elements of bar, one could not store the values of constraints SIXX,... on these elements (which know only the generalized efforts: N , MX , ...)

3.13.1 Operand TYPE_CHAM= 'NOEU'

This keyword is used to force the fields projected to be fields "with the nodes". This keyword is used systematically by the order MACR_LIGN_COUPE, because one cannot create fields by elements on the "fictitious" model of beam created by this macro-order of visualization.

3.13.2 How to project a field ELNO discontinuous on a border?

Problem:

That is to say a formed structure by two zones A and B having a common border.

This structure is modelled twice $MO1$ and $MO2$. These 2 models correspond to 2 different grids $MA1$ and $MA2$.

Also let us suppose that the grids respect the border between the zones A and B , i.e. that there exists in each grid two $GROUP_MA$ (A and B) correspondents at the zones A and B .

That is to say a field by elements "ELNO" (for example 'HYDR_ELNO') known on $MO1$. One wants to project it on $MO2$.

How to make so that values of the field on A (respectively B) that is to say projected on A (respectively B)?

One wants to prevent that the values of A "do not pollute" the zone B and reciprocally.

This situation can occur as soon as there exists an important discontinuity of the field on the border enters A and B .

Answer:

One cannot solve this problem with only one call to PROJ_CHAMP.

Indeed, only method to project a field ELNO is the method 'COLLOCATION'. This method is based on the localization of the nodes of the grid MA2 in the meshes of the grid MA1.

The geometrical phase of pairing of the method 'COLLOCATION' led to construction D' a structure of data allowing to answer the question:

- For a node $N2$ of MA2, in which mesh $IMAI$ of MA1 is this node and which is its position in this mesh?

For the nodes of the border enters A and B , there is only one possible answer: either the node is associated with a mesh of A or it is associated with a mesh of B .

In general, association is unforeseeable by the user.

It can impose that all the nodes of the border are associated with A (or with B) by using the key mode VIS_A_VIS, but that will not solve the initial problem. Indeed, if it imposes for example, that the nodes are associated with the zone A , values of A the meshes "will pollute" of B on the elements which touch the border.

While using VIS_A_VIS, it can only choose "Which pollutes which?"

In short, method 'COLLOCATION' is made to project continuous-current fields and it will be always unable to project easily and correctly a strongly discontinuous field.

Solution of skirting:

To solve the problem posed, it is necessary to use 2 times PROJ_CHAMP to project the zones independently A and B .

2 fields are obtained CHA and CHB that it is then necessary to assemble with the order CREA_CHAMP/OPERATION='ASSE'.

This "solution" is illustrated in the test zzzz304a.

3.14 Remarks on the projection of fields ELGA of a model X-FEM

An element X-FEM can be Re-cut out in a variable number of subelements. The number of points of Gauss of such an element is thus variable.

In Code_Aster, one cannot take into account this variable number of points: the field is oversized. By convention, the unutilised points are positioned geometrically at the item (0,0,0).

On these points, the values of the field are arbitrary.

When one projects a field ELGA on a model X-FEM, these fictitious points, if they are found geometrically apart from the model origin, will cause an alarm CALCULEL5_48 indicating that certain

points were projected on remote meshes. If the coordinates of the "remote" points are (0,0,0), one should not worry some.

3.15 Operand **DISTANCE_MAX**

To project the grid *MA1* on the grid *MA2*, method (COLLOCATION) seek in which element of the grid *MA1* each node is of *MA2*, then the value using the functions of form of the element interpolates. When that a node of *MA2* is not in any element of the grid *MA1*, the method connects the node and the point (of the edge) of the element nearest. It interpolates the value using the functions of form of the element and that even if the node is "far" from this element.

If it be wished that a node which is not in any the elements of the grid *MA1*, is not concerned with projection, one uses the operand **DISTANCE_MAX**. This operand makes it possible to give the maximum distance which one authorizes between the node and the element nearest.

If the node does not answer the criterion of proximity the field will not be project on this node (i.e the node will not carry any component).

There is no value by default for **DISTANCE_MAX**. What wants to say that by default, the field will be prolonged apart from the matter also far one will need it.

3.16 Operand **ALARME= 'YES' / 'NOT'**

When a node of the grid "2" is found "far" from the elements of the grid "1", the code transmits a message of alarm (CALCULEL5_48). One can avoid these alarms while using **ALARME='NON'**.

3.17 Operand **DISTANCE_ALARME = d_ala**

A node of the grid "2" is regarded as "far" from the grid "1" if:

- The distance from the node to the mesh nearest to the grid "1" is higher than 10% of the size of this mesh.
It is this criterion (relative) which is used if **DISTANCE_ALARME** is not provided.
- The distance from the node to the mesh nearest to the grid "1" is higher than **d_ala** if the keyword **DISTANCE_ALARME** is used (absolute criterion).

3.18 Operand **PROL_ZERO= 'NOT' / 'YES'**

For the fields with the nodes:

- If a node is not concerned with projection (**DISTANCE_MAX** nondefinite or beyond this distance), no value is assigned to this node. The user can choose **PROL_ZERO='OUI'** in order to affect 0 on this node.
- When the user wants to impose a classification on the fields of **SD_RESULTAT**, it must use the keyword **NUME_DDL**. If this classification imposes that a given node carries components and that the node is found in the preceding case without value to project, an error message is transmitted. To avoid it, the user can choose **PROL_ZERO='OUI'** in order to affect 0 on this node.

For the fields with the elements:

- The keyword **PROL_ZERO** can also be used during the projection of the fields by elements. It has the same direction: one assigns the field to "zero" where projection could not be made.

3.19 Operand **NUME_DDL = naked**

This keyword makes it possible "to number" the fields projected (for a structure of data of type "mode") according to classification (**naked**). It is necessary if one wishes to use the result of the order in later calculations (orders **REST_GENE_PHYS**, **PROJ_BASE**,...).

3.20 Selection of the sequence numbers

cf [U4.71.00].

3.21 Operand **NOM_PARA**

NOM_PARA = will lpara,

This keyword is followed of a list of names of parameters of SD_RESULTAT evo1. Parameters of evo1 correspondent with these names will be recopied in the structure of data produced by the order (resu).

Example: during the projection of clean modes, one can indicate:

```
NOM_PARA = ('AMOR_REDUIT', 'MASS_GENE')
```

3.22 Operand TITLE

```
TITLE = titr,
```

Title which one wants to give to the concept result.

3.23 Operand INFORMATION

```
INFORMATION = / 1, [DEFECT]  
              / 2,
```

Level of impression.

4 Example

Calculations thermics and mechanics on two different grids.

```
ma1 = LIRE_MAILLAGE (...)  
mo1 = AFFE_MODELE (MAILLAGE=ma1,  
                  AFFE=_F (TOUT=' OUI', PHENOMENE=' THERMIQUE',...),)  
  
evo1 = THER_LINEAIRE (MODEL = mo1,...)  
  
ma2 = LIRE_MAILLAGE (...) # grid more refined  
mo2 = AFFE_MODELE (MAILLAGE= ma2,..., PHENOMENE='MECHANICAL',...)  
  
evo2 = PROJ_CHAMP (METHODE= 'COLLOCATION', RESULTAT= evo1,  
                  NOM_CHAM= 'TEMP', MODELE_1= mo1, MODELE_2= mo2,)  
  
chmat2 = AFFE_MATERIAU (...,  
                        AFFE_VARC=_F (NOM_VARC=' TEMP', EVOL= evo2,...)  
                        )
```