

## Operator INFO\_MODE

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### 1 Drank

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This command allows to **count** and save (in a `sd_table`) **the number of eigenvalues understood** in:

**An interval of the real axis** (for the generalized problems GEPs standard with symmetric real matrixes).

**A disc of the complex plane** (for all the other the quadratic cases, other GEPs and all problems QEPs).

When one deals with GEPs standards, the execution of this procedure requires generally only one factorization LDLT by mode. When they are disseminated in the complex plane, the procedure is much more expensive. In this case, case it is thus rather to hold for the simplified problems smalls (lower than 1000 degrees of freedom).

The call to this operator is recommended as **checking/calibration a priori model**. It also makes it possible to define **balanced intervals of search and containing a reasonable number of eigenvalues** (typically a few tens). And this, in order to optimize the costs of the later modal operators and not to degrade the accuracy of their results.

**To treat effectively a GEP standard<sup>1</sup>Actuellement<sup>1</sup>**, one proposes to proceed in several stages:

**To gauge** the zones of interest by precalculations using only `INFO_MODE` (into sequential or, if possible, parallel) on lists of frequencies (resp. critical loads) given;

**To start again** one or more computations `MACRO_MODE_MECA` or `MODE_ITER_SIMULT+OPTION='BANDE'` while basing itself on these initial calibrations.

For the supercomputing, the `INFO_MODE2Tout operator2`, can profit from two levels of parallelism. The savings of time can reach a factor 70 on a hundred processors, and the gains in peak report a factor 2. The implementation of parallelism is described in the dedicated paragraph of documentation [U2.06.01].

This operator produces a concept `sd_table`.

In a first approach one can be satisfied to inform the parameters: `MATR_*`, `TYPE_MODE` and `FREQ` (or `CHAR_CRIT` or `*_CONTOUR`).

This operator is complementary to operators `MACRO_MODE_MECA` [U4.52.02], `MODE_ITER_SIMULT` [U4.52.01] and `MODE_ITER_INV` [U4.52.04].

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<sup>1</sup> , the very majority of the cases.

<sup>2</sup> like `MACRO_MODE_MECA`.

Warning : The translation process used on this website is a "Machine Translation". It may be imprecise and inaccurate in whole or in part and is provided as a convenience.

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## 2 Syntax

Tb [table\_sdaster] = Standard

### INFO\_MODE # of problem

```

◇TYPE_MODE=/ "DYNAMIQUE", [DEFAULT]
/ "MODE_FLAMB",
/ "MODE_COMPLEXE",
/ "GENERAL".

```

# If TYPE\_MODE= 'DYNAMIQUE'

### # Characteristic of computation

```

◇MATR_RIGI=A , / [matr_asse_depl_r]
/ [matr_asse_depl_c]
/ [matr_asse_temp_r]
/ [matr_asse_pres_r]
/ [matr_asse_gene_r]
/ [matr_asse_gene_c]
◇MATR_MASS=B , / [matr_asse_depl_r]
/ [matr_asse_temp_r]
/ [matr_asse_pres_r]
/ [matr_asse_gene_r]

```

# the number of frequencies delimiting the intervals of computation is noted nb\_freq  
 ◇FREQ=l\_f [l\_R]

### # Parameters of the method of counting of STURM TYPE

```

◇COMPTAGE=_F (
  ◇METHODE=/ "AUTO", [DEFAULT]
/ "STURM TYPE".
◇SEUIL_FREQ=/f_seuil [R]
◇PREC_SHIFT=/p_shift / 0.01 [DEFAULT] [R]
◇NMAX_ITER_SHIFT=/n_shift / 0.05 [DEFAULT] [I]
/3 [DEFAULT]
)

```

# If TYPE\_MODE= 'MODE\_FLAMB'

### # Characteristic of computation

```

◇MATR_RIGI=A , / [matr_asse_depl_r]
/ [matr_asse_depl_c]
/ [matr_asse_temp_r]
/ [matr_asse_pres_r]
/ [matr_asse_gene_r]
/ [matr_asse_gene_c]
◇MATR_RIGI_GEOM=B , / [matr_asse_depl_r]
/ [matr_asse_temp_r]
/ [matr_asse_pres_r]
/ [matr_asse_gene_r]

```

# the number of critical loads delimiting the intervals of computation is noted nb\_mode\_flamb  
 ◇CHAR\_CRIT=l\_c [l\_R]

Warning : The translation process used on this website is a "Machine Translation". It may be imprecise and inaccurate in whole or in part and is provided as a convenience.

## # Parameters of the method of counting of STURM TYPE

```
◇COMPTAGE=_F (
  ◇METHODE=/ "AUTO", [DEFAULT]
  / "STURM TYPE".
  ◇SEUIL_CHAR_CRIT=/c_seuil [R]
  / 0.01 [DEFAULT]
  ◇PREC_SHIFT=/p_shift [R]
  / 0.05 [DEFAULT]
  ◇NMAX_ITER_SHIFT=/n_shift [I]
  /3 [DEFAULT]
)
```

# If TYPE\_MODE= 'MODE\_COMPLEXE'

## # Characteristic of computation

```
◆MATR_RIGI=A , / [matr_asse_depl_r]
/ [matr_asse_depl_c]
/ [matr_asse_temp_r]
/ [matr_asse_pres_r]
/ [matr_asse_gene_r]
/ [matr_asse_gene_c]
◆MATR_MASS=B , / [matr_asse_depl_r]
/ [matr_asse_temp_r]
/ [matr_asse_pres_r]
/ [matr_asse_gene_r]
◇MATR_AMOR=C , (only in QEP)/ [matr_asse_depl_r]
/ [matr_asse_temp_r]
/ [matr_asse_pres_r]
/ [matr_asse_gene_r]
◇TYPE_CONTOUR=' CERCLE' [DEFAULT]
◆RAYON_CONTOUR=rayon [R]
◇CENTER_CONTOUR=/center [C]
/0.0 +0.0j [DEFAULT]
```

## # Parameters of the method of counting APM

```
◇COMPTAGE=_F (
  ◇METHODE=/ "AUTO", [DEFAULT]
  / "APM".
  ◇NBPOINT_CONTOUR=/nb_point [I]
  / 40 [DEFAULT ]
  ◇NMAX_ITER_CONTOUR=/n_contour [I]
  /3 [DEFAULT]
)
```

# If TYPE\_MODE= 'GENERAL'

## # Characteristic of computation

```
◆MATR_A=A , / [matr_asse_depl_r]
/ [matr_asse_depl_c]
/ [matr_asse_temp_r]
/ [matr_asse_pres_r]
/ [matr_asse_gene_r]
/ [matr_asse_gene_c]
◆MATR_B=B , / [matr_asse_depl_r]
/ [matr_asse_temp_r]
```

```

/ [matr_asse_pres_r]
/ [matr_asse_gene_r]
◇MATR_C=C , (only in QEP)/ [matr_asse_depl_r]
/ [matr_asse_temp_r]
/ [matr_asse_pres_r]
/ [matr_asse_gene_r]
◇CHAR_CRIT=1_c [1_R]

# If CHAR_CRIT==None
◇TYPE_CONTOUR=' CERCLE' [DEFAULT]
◇RAYON_CONTOUR=rayon [R]
◇CENTER_CONTOUR=/center [C]
/ 0.0+0.0j [DEFAULT]
◇COMPTAGE=_F (
◇METHODE=/ "AUTO", [DEFAULT]
/ "STURM TYPE", (if CHAR_CRIT )
/ "APM". (if *_CONTOUR)

# Parameters of the method of counting
# If STURM TYPE
◇SEUIL_CHAR_CRIT=/c_seuil [R]
/ 0.01 [DEFAULT]
◇PREC_SHIFT=/p_shift [R]
/ 0.05 [DEFAULT]
◇NMAX_ITER_SHIFT=/n_shift [I]
/3 [DEFAULT]

# If APM
◇NBPOINT_CONTOUR=/nb_point [I]
/ 40 [DEFAULT ]
◇NMAX_ITER_CONTOUR=/n_contour [I]
/3 [DEFAULT]
)

# Linear solver and parallelism
◇SOLVEUR=_F (For more details to see the document [U4.50.01]).
# In parallel, one advises particularly parameter setting METHODE=' MUMPS'+RENUM=' QAMD' .
◇NIVEAU_PARALLELISME=/ "COMPLET", [DEFAULT]
/ "PARTIAL".
# Activated only in parallel mode ( nb_proc >1) and licit if METHODE=' STURM' .
# option" COMPLET "functions some is the direct linear solver, if nb_proc = nb_freq -1 (resp.
nb_mode_flamb -1). With the option "PARTIAL , only " SOLVEUR=_F (METHODE=' MUMPS")
is licit.

#
# Various
◇INFO=/1 [DEFAULT]
/2
◇TITER=tit [kN]
) ;

```

## 3 Operands

### 3.1 Principles

This command makes it possible to count the number of eigenvalues understood in (cf appears 3ab):  
 An interval of the real axis (for the generalized problems GEPs standard with symmetric real matrixes): "GENERAL" key word TYPE\_MODE=' DYNAMIQUE' or "MODE\_FLAMB " or.  
 A disc of the complex plane (for all the other the quadratic cases, other GEPs and all problems QEPs): key word TYPE\_MODE=' MODE\_COMPLEXE' or "GENERAL".

This number of eigen modes is traced in the message file for each interval of the real axis or for the portion of the plane complexes selected (cf figure 1). One points out also the characteristics of these zones of interest.

```

-----
VERIFICATION OF the FREQUENCY SPECTRUM (METHODE OF STURM TYPE)

LE FREQUENCY many IN the TAPE N1 OF
BORNES (0.000E+00, 1.000E+01) IS 20
-----

LE FREQUENCY many IN the TAPE N2 OF
BORNES (1.000E+01, 2.000E+01) IS 43
.....

LE NOMBRE OF FREQUENCIES IN the TAPE N 6 OF
BORNES (5.000E+01, 6.000E+01) ARE 139
-----
    
```

Figure 1. \_Displays in the message file of a INFO\_MODE on a series of frequencies  $FREQ=(0. , 10. , 20. , ..., 50. , 60.)$  for a problem of DYNAMIQUE.

All these elements are stored in a sd\_table (cf appears 2ab) that one can print (via an IMPR\_TABLE) or re-use (by sequences with MODE\_ITER\_SIMULT). The overcost of this operator can then become almost negligible since one pools the total information released with other modal operators.

```

#TABLE_SDASTER
FREQ_MIN      FREQ_MAX      BORNE_MIN_EFFECT  BORNE_MAX_EFFECT  NB_MODE
0.000000E+00  1.000000E-02  0.000000E+00     1.000000E-02     3
1.000000E-02  5.000000E-02  1.000000E-02     5.000000E-02     3
5.000000E-02  5.500000E-02  5.000000E-02     5.500000E-02     1
5.500000E-02  6.000000E-02  5.500000E-02     6.000000E-02     0
6.000000E-02  1.000000E-01  6.000000E-02     1.000000E-01     3

#TABLE_SDASTER
CHAR_CRIT_MIN  CHAR_CRIT_MAX  BORNE_MIN_EFFECT  BORNE_MAX_EFFECT  NB_MODE
-1.000000E+06  -5.000000E+05  -1.000000E+06     -5.000000E+05     1
-5.000000E+05  0.000000E+00   -5.000000E+05     0.000000E+00     3
0.000000E+00   1.000000E+05   0.000000E+00     1.000000E+05     0
1.000000E+05   1.100000E+06   1.000000E+05     1.100000E+06     5
    
```

Figure 2ab. \_N°1 Example of array generated by a INFO\_MODE on a series of frequencies  $FREQ=(0. , 1.E-2, ..., 1.E-1)$  for a problem of dynamics. Extract of sdx201a.mess. N°2 example of array generated by an INFO\_MODE on a series of critical loads  $TANK\_CRIT=(- 1.E+6, - 5.E+5, ..., 1.1E+6)$  for a problem of buckling . Extracted from sdx504a.mess the call

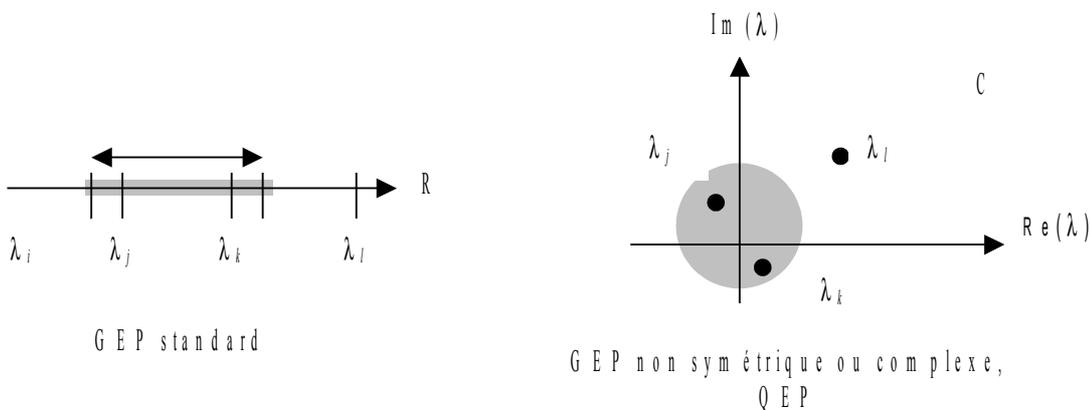
to this operator is recommended as checking/calibration a priori model . It also makes it possible to define intervals of search containing a reasonable number of eigenvalues (typically about forty modes) in order to optimize the costs of the later modal operators and not to degrade the accuracy of their results. Typically

, one advises to search the modes per packages of forty environ3En sequential<sup>3</sup>, consumption in time and memory is not optimal any more and the quality of the modes obtained is degraded. It is then to better use several frequential tapes (or of critical loads) directly in several calls with `MODE_ITER_SIMULT` [U4.52.03], or, indirectly, via the macro `MACRO_MODE_MECA` [U4.52.02]. Ideally

, to treat a standard GEP effectively, one proposes to proceed in several stages: To gauge the zones of interest by precalculations using only `INFO_MODE` (into sequential or, if possible, parallel) on lists of frequencies (resp. critical loads) given; To start again one or more computations `MACRO_MODE_MECA` or `MODE_ITER_SIMULT+OPTION='BANDE'` while basing itself on these initial calibrations.

To save time, one can even pool (and it is strongly advised!) part of the cost computation of the initial `INFO_MODE` by notifying with the `MODE_ITER_SIMULTs` the name of the generated `sd_table`. This sequence can thus return the overcost of negligible `INFO_MODE` and effectively guide modal computation. Contrary to `MODE_ITER_SIMULT`, `MACRO_MODE_MECA` cannot re-use the `sd_table` generated at the stage n°1. On the other hand, into sequential and especially in parallel, it allows notable gains in time, peak report and accuracy when large computations are treated (in the face of mesh and/or of many required modes). Dimensioned

intensive computation, operator `INFO_MODE`, just like `MACRO_MODE_MECA`, profits potentially from two levels of parallelism (cf key word `NIVEAU_PARALLELISME`). From where savings of time of a factor up to 70 on a hundred processors and of the gains in peak report until a factor 2. Appear



3ab. Two distinct problems of enumeration: in a segment of the real axis and a finished portion of the complex plane (for time that a disc). In

the first case, when one seeks to count the eigenvalues strictly included in a segment of the real axis, one uses the method known as of "Sturm type", in the second case method APM. Their theories and algorithmies are detailed in documentation of reference [R5.01.04]. When

one deals with GEPs standards, the execution of this procedure does not require généralement<sup>4</sup>Sauf a factorization LDLT by mode (`METHODE = 'STURM TYPE'`). When they are disseminated in the complex plane, the procedure is much more expensive (`METHODE='APM'`) because it requires, in

- 3 mode. With `MACRO_MODE_MECA parallel`, one can more quickly obtain a computation by taking only about twenty modes. Beyond that
- 4 the value is close to an eigen mode, in which case "is shifted it" (cf key word `NMAX_ITER_SHIFT`) to limit certain numerical instabilities. that

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general, of the hundreds of factorizations. In this case, case it is thus rather to hold for the simplified problems smalls (lower than 1000 degrees of freedom). Let us note

that this last method APM is still the object of active searches. Its robustness, for time, is thus not guaranteed. It is to be used while having taken well care to read associated documentation. Characteristics

## 3.2 of the modal problem: operands MATR\_RIGI/MATR\_A/MATR\_MASS/MATR\_RIGI\_GEOM/MATR\_B/MATR\_AMOR/MATR\_C the table

below represents the operands to be used according standard to key word TYPE\_MODE . "

GENERAL"			
TYPE_MODE "DYNAMIQUE	" "MODE_FLAMB	" "MODE _COMPLEXE	" ♦
MATR_RIGI = A ♦	MATR_RIGI = A ♦	MATR_RIGI = A ♦	MATR_A = A ♦
MATR_MASS = B ♦	MATR_RIGI_GEOM = B ♦	MATR_MASS = B ♦	MATR_B = B Without
Object Without	Object ♦	MATR_AMOR = C ♦	MATR_C = C These operands

makes it possible to inform the matrixes (assembled or généralisées5Cette<sup>5</sup> the modal problem. These matrixes can be symmetric or not. They are real except the matrix which can **A** be, either real, or complex. The data

of formula **A B** to define the generalized modal problem (GEP) (cf [R5.01.01]) studied formula

$$\mathbf{A} \mathbf{u} = \lambda \mathbf{B} \mathbf{u} \quad (\text{GEP}_{\text{dynamique}})$$

the classical case of dynamics (TYPE\_MODE=' DYNAMIQUE'), formula **A** the stiffness matrix (symmetric real) and formulates **B** the mass matrix (symmetric real). The eigenvalue  $\lambda$  is then connected to the eigenfrequency by  $f$  the formula: . It  $\lambda = (2\pi f)^2$  is real positive. In

the case of the theory of linear buckling (TYPE\_MODE=' MODE\_FLAMB'), formula

$$\mathbf{A} \mathbf{u} - \lambda \mathbf{B} \mathbf{u} = \mathbf{0} \quad (\text{GEP}_{\text{flambement}})$$

**A** the stiffness matrix (symmetric real) and formulates **B** stiffness matrix (symmetric real). The eigenvalue is called  $\lambda$  critical load. It is real. As

mentioned in the preceding table, these matrixes will be indicated, respectively, for the dynamics by MATR\_RIGI/MATR\_MASS and, in buckling, by MATR\_RIGI/MATR\_RIGI\_GEOM. Only the method known as of "STURM TYPE " is licit in these two cases. When

one of the two matrixes is not symmetric any more or comprises complex terms (e.g. to take into account hysteretic damping), the eigenvalues are potentially complex. To deal with this problem it is necessary to initialize TYPE\_MODE with" MODE \_COMPLEXE' and only method APM is then licit. The data

of formula **A B C** to define the modal problem quadratic (QEP) (cf [R5.01.02]) studied In this case,

5 notion of generalized matrix have nothing to dohas nothing to do with that of generalized modal problem!) characterizing

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$$(\mathbf{A} + \lambda \mathbf{C} + \lambda^2 \mathbf{B}) \mathbf{u} = \mathbf{0} \quad (\text{QEP})$$

case the eigenvalues are potentially complex. To deal with this problem it is necessary to initialize TYPE\_MODE with "MODE\_COMPLEXE". Often formula **A** the stiffness matrix, Formula One **C** taking into account viscous damping and/or gyroscopic effects and formulates **B** stiffness matrix. As mentioned in the preceding table, these matrixes will be indicated by MATR\_RIGI/MATR\_MASS/MATR\_AMOR and only method APM is licit. The TYPE

\_MODE='GENERAL' makes it possible to solve value problems clean in the case general. One then makes play matrixes formulates **A** **B** formula **C** which one wishes. As mentioned in the preceding table, these matrixes will be indicated by MATR\_A/MATR\_B/MATR\_C. According to the cases, only the method of Sturm type (if MATR\_C is not indicated and if the two other matrixes are real symmetric) or method APM (all other cases) are licit. Operand

### 3.3 TYPE\_MODE $\diamond$ TYPE

```
_MODE=/ "DYNAMIQUE" [DEFAULT ]/"MODE_FLAMB
        "/"GENERAL
        " "MODE_COMPLEXE"
        /This key word
```

makes it possible to define the nature of the modal problem in treating: pre-to estimate the frequency spectrum of vibration (classical case of "DYNAMIQUE"), to do it in term of critical loads (case of the theory of linear buckling "MODE\_FLAMB") or to gauge that of a nonstandard GEP or a QEP in a portion of the complex plane ("MODE\_COMPLEXE"). One can also search the eigenvalues and the modes associated with a general matric system ("GENERAL"). For more precise details one will be able to refer to the description of the §3.2. With resulting

from this choice, the user must specify the characteristics of his control field: for  
 "DYNAMIQUE": list frequencies via **FREQ**, for  
 "MODE\_FLAMB": list critical loads via **CHAR\_CRIT**, for  
 "MODE\_COMPLEXE": zone complex plane via **TYPE/RAYON/CENTER\_CONTOUR**, for  
 "GENERAL": according to the case, one is proceeds as for "MODE\_FLAMB" (if **MATR\_C** is not indicated and if the two other matrixes are real symmetric), that is to say as for "MODE\_COMPLEXE" (all other cases). Operand

### 3.4 FREQ $\diamond$ FREQ

```
= l_f List
```

of frequencies (in Hertz) defining the intervals which one wants to gauge formula  $l_f = (f_i)$  nb\_freq the number of frequencies of this list). One then searches the number of eigenvalues in the sub-bands formulates  $[\lambda_i, \lambda_{i+1}]$  formula  $\lambda_* = (2\pi f_*)^2$  list must comprise at least two values. These values must be arranged by order strictly growing and all positive. This key word must be used if TYPE\_MODE= 'DYNAMIQUE'. Only the method of counting of the STURM TYPE type is then licit. Note:

#### Each

frequency is treated only once: as a lower limit of the first sub-band for the first of the list, as a higher limit of the sub-bands which follow for the other frequencies. In particular, if this frequency is judged too near to an eigenvalue, it is shifted (possibly several times of parameters **PREC\_SHIFT/NMAX\_ITER\_SHIFT** etc). This shift "of the shift" is always operated towards the external one of the sub-band considered. If the shift of the lower limit makes it larger than the higher limit, the process stops in **ERREUR\_FATALE**. This mode

of shift makes more robust and consisting the later re-uses of this `sd_table` by one or more `MODE_ITER_SIMULT`. One avoids in particular coverings of sub-bands which could occur until V10. The initial limits of each one of these sub-bands are saved in fields `FREQ_MIN/MAX` of each line of the produced array (cf appears 2a). For each one of these couples, one mentions the limits actually used by the test of Sturm type (i.e. after possible shifts), `BORNE_MIN/MAX_EFFECT`, as well as the number of found modes: `NB_MODE`. Operands

## 3.5 CHAR\_CRIT CHAR\_CRIT

= `l_c` List

of critical loads defining the intervals which one wants to gauge formula  $l_c = (\lambda_i)$ , `nb_mode_flamb` the number of critical loads of this list). One then searches the number of eigenvalues in the sub-bands formulates  $[\lambda_i, \lambda_{i+1}]$  list must comprise at least two values. These values must be arranged by order strictly growing. They must be of real type. This key word must be used if `TYPE_MODE = 'MODE_FLAMB'` or if `TYPE_MODE = 'GENERAL'` (if `MATR_C` is not indicated and if the two other matrixes are real symmetric). Only the method of counting of the STURM TYPE type is licit. Note:

### Each

critical load is treated only once: as a lower limit of the first sub-band for the first of the list, as a higher limit of the sub-bands which follow for the other frequencies. In particular, if this load is judged too near to an eigenvalue, it is shifted (possibly several times cf parameters `PREC_SHIFT/NMAX_ITER_SHIFT` etc). This shift "of the shift" is always operated towards the external one of the sub-band considered. If the shift of the lower limit makes it larger than the higher limit, the process stops in `ERREUR_FATALE`. This mode of shift makes more robust and consisting the later re-uses of the `sd_table` by one or more `MODE_ITER_SIMULT`. One avoids in particular coverings of sub-bands which could occur until V10. The initial limits of each one of these sub-bands are saved in fields `CHAR_CRIT_MIN/MAX` of each line of the produced array (cf appears 2b). For each one of these couples, one mentions the limits actually used by the test of Sturm type (i.e. after possible shifts), `BORNE_MIN/MAX_EFFECT`, as well as the number of found modes: `NB_MODE`. Operands

## 3.6 TYPE RAYON/CENTER\_CONTOUR if TYPE

`_MODE = 'MODE_COMPLEXE'` or if `TYPE_MODE = 'GENERAL'` (if `MATR_C` is indicated ou/et if one of the matrixes is asymmetric or complex)  $\diamond$ TYPE

```
_CONTOUR=' CERCLE' [ [DEFAULT ]  $\diamond$ RAYON
_CONTOUR=rayon [ R]  $\diamond$ CENTER
_CONTOUR=/center [C] /0.0 +
0.0j [DEFAULT ] These key words
```

define the type of contour inside of which one seeks the eigenvalues like its characteristics. For time one can choose only one contour of the type "RINGS" (which thus delimits the disc of control). One mentions his center (a complex number) and his radius (a positive reality). Note:

### In any

rigor, this radius must be higher than "zero modal". I.e. higher than the value below which one considers than an eigenvalue is null or than two eigenvalues are confused if one speaks about their variation. Contrary to the values of `FREQ`, the units are not here in frequency, but in pulsation if one makes the analogy with problem `DYNAMIQUE`. As for a `TYPE_MODE='MODE_FLAMB'`, the unit of the characteristics of contour no transformation undergoes. That makes it possible method `APM` to treat all the types of problems. The array produced with option `TYPE_MODE='MODE_COMPLEXE'` contains, besides the number of eigenvalues (`NB_MODE`), three real making it possible to describe the search criteria for method `APM`. The two first are `CENTER_R` and `CENTER_I`, the parts real and imaginary of the complex number which corresponds to the center of the disc of search. The third parameter, `RADIUS`, are the radius (real strictly positif > 1.D-2) of the disc. Factor key word

## 3.7 COMPTAGE Once

defined the type of control field (segment or disc), it remains to fix the method of enumeration and its parameters. `◇METHODE`

```
= "AUTO          ", [DEFAULT      ]/"STURM TYPE
      ",/"APM
      ". If one
```

deals with a problem of the type "DYNAMIQUE" or "MODE\_FLAMB", only the methods "STURM TYPE" and "AUTO" are authorized. In the same way for "MODE\_COMPLEXE" and "APM"/"AUTO". In the "GENERAL" case, the three methods are available and value "AUTO" takes all its meaning then! It chooses for the user between `STURM TYPE` and `APM` according to the characteristics of the modal problem: Either

it is about a standard GEP (two real symmetric matrixes): method of `STURM TYPE`. In all other cases (atypical GEP with asymmetric and/or complex matrix or QEP): method `APM`. If one leaves mode "AUTO" parameterized by default, the operator automatically chooses the method according to the type of selected study. One left this value knowingly, even in the cases which comprise only one alternative, to facilitate ergonomics. If one

is mistaken in `METHODE`, an alarm appears and the operator chooses the most adapted method automatically or stops in `ERREUR_FATALE`, according to the cases. Note:

### One can

use method `APM` to count the modes of a standard GEP by posing `TYPE_MODE='MODE_COMPLEXE'`. That makes it possible to compare and validate the two methods of counting (cf `SDLL123a` benchmark). # If

```
TYPE_MODE= `DYNAMIQUE' ◇SEUIL
      _FREQ   =/f_seuil           [R] /0.01
      [DEFAULT      ] ◇
PREC_SHIFT   =/p_shift           [R] /0.05
      [DEFAULT      ] ◇
NMAX_ITER_SHIFT =/n_shift       [I] /3      [DEFAULT
] # If
```

`TYPE_MODE='MODE_FLAMB'` or "GENERAL" (if `MATR_C` is not indicated and if the two other matrixes are symmetric real) ◇SEUIL

```
_CHAR_CRIT   =/c_seuil           [R] /0.01
      [DEFAULT      ] ◇
PREC_SHIFT   =/p_shift           [R] /0.05
```

Warning : The translation process used on this website is a "Machine Translation". It may be imprecise and inaccurate in whole or in part and is provided as a convenience.

```

                                [DEFAULT]
NMAX_ITER_SHIFT =/n_shift      [I] /3      [DEFAULT]
                                ] ◇
] These parameters

```

are used only by the method of STURM TYPE . Parameters

SEUIL\_\*make it possible to define "the zero modal one", i.e. the value in on this side which it is considered that the eigenvalue is null. If one is in dynamics one transforms this value into pulsation while

$$omecor=(2\pi f\_seuil)^2$$

in buckling one keeps it such as it is.

$$omecor=c\_seuil \text{ Other}$$

parameters, PREC\_SHIFT and NMAX\_ITER\_SHIFT , are related to the algorithm of shift of the limits of the interval (cf [R5.01.04] §3.2) when one realizes that those are very close to an eigenvalue. Coarsely these limits formulates  $f_{min}$  formulates  $\lambda_{min}$  ) or formulates  $f_{max}$  . formulate  $\lambda_{max}$  are then shifted towards the outside of the segment of p\_shift % . If the dynamic matrix thus rebuilt is always considered to be "numerically singular", one again Re-shifts after having emitted an ALARME . One tries this shift n\_shift time. formulate

$$\lambda_{min}^- = \lambda_{min} - \max(omecor, 2^{(i-1)} \times p\_shift \times |(\lambda_{min})|) \text{ attempt) formula}$$

$$\lambda_{max}^- = \lambda_{max} + \max(omecor, 2^{(i-1)} \times p\_shift \times |(\lambda_{max})|) \text{ attempt) In fact}$$

, in dynamics as in buckling the shift takes place same way. Stricto - censu, in dynamics these are thus not the frequencies that one shifts, but pulsations. Another accuracy, the shift is in fact, by preoccupations with an effectiveness, dichotomic: p\_shift % the first time, 2xp\_shift% second time etc This process must make it possible quickly to move away from the "zone of singularity" to lower costs. A contrario , one should not too much increase the values of these parameters, because through shifts, the resulting limits can prove to be very different from the initial limits. Moreover

, to remain coherent with "the zero modal one" (noted omechor here ) : One does not shift a value lower than this minimum (from where the max in the formulas above), So upon the departure

, the measured limit is lower than this "zero" formula  $|\lambda_*| < omechor$  ) one fixes it at more or less this value (according to whether this limit is positive or negative). One then allows any more no shift. Note:

## A limit

of the interval formula  $\sigma$  to an eigenvalue, when factorization LDLT of the dynamic matrix associated with this limit (for example that of a GEP is written formula  $Q(\sigma):=A-\sigma B$  to a loss of decimal of more than NPREC digits (value parameterized under the key word solver) . While exploiting the value of this parameter (NPREC=7, 8 or 9), one can then avoid the expensive refactorisations which these shifts imply when this numerical singularity is not very marked. In the same way , while exploiting the numerical parameters of the linear solvers (for example: METHODE , RENUM, PRETRAITEMENTS...), one can also influence this criterion of singularity. # If

TYPE\_MODE= 'MODE\_COMPLEXE' or "GENERAL " (if MATR\_C is indicated ou/et if one of the two other matrixes is asymmetric or complex) ◇NBPOINT

```

    _CONTOUR =/nb_point      [I] /40      [DEFAULT]
                                ] ◇
NMAX_ ITER_CONTOUR =/n_contour      [I] /3      [DEFAULT]
                                ] These parameters

```

are used only by method APM. The two

parameters precedent, NB\_POINT \_CONTOUR and NMAX\_ ITER\_CONTOUR, are used only with method APM. They are crucial for its robustness and they dimension its time computation (a

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computation with `nb_point = 80` will last longer than a computation with `nb_point = 40`). The value `nb_point` gives the number of point of discretization which is positioned along contour. This discretization must be enough fine "to capture" all spectral information. Ideally, this value must be built-in with at least six times the number of modes which one discounts to find in the circle. If one has no idea a priori *this* number, it should be fixed at a value not too low: for example, 40 or 60. Note:

### Attention

, if this figure is too large (for example 1000), according to the size of the problem, as it implies as many factorizations LDLT, computation can be very long! Established

algorithm APM will converge only when 3 successive evaluations amongst eigenvalues provide the same one result. The differences between these three evaluations lies only in the degree of discretization of contour. One starts by discretizing with, then  $k_- = \text{nb\_point}/2$  with and finally  $k = \text{nb\_point}$  with. If  $k_+ = 2 \text{nb\_point}$  these three levels of discretization of contour produce an estimate amongst identical eigenvalues, the algorithm is regarded as converged. Its result is then this integer. If not, one doubles these three levels of discretizations according to the following permutation formulates

$$k_- \leftarrow k \quad k \leftarrow k_+ \quad k_+ \leftarrow 2 k_+$$

revalues the numbers of eigenvalues with these three levels of discrétisation<sup>6</sup> Bien<sup>6</sup> are identical, convergence is reached, if not one continues. One reiterates this dichotomic heuristics to the maximum `n_contour time`. If this process did not converge or if its result is incoherent (strictly negative integer), one stops in `ERREUR_FATALE`. Operand

## 3.8 INFO ◇

INFO =/1 [DEFAULT ] /2 Indicates

the level of printing in the message file . 1: Printing of result (and of the principal stages of the algorithm if APM). 2: Rather more detailed printing for developer. Operand

## 3.9 TITER the title

which will be given to the produced array. Factor key word

## 3.10 solver ◇ SOLVEUR

=\_F (), One has

access to all the parameters of the direct linear solvers (METHODE = 'LDLT'/'MULT\_FRONT'/'MUMPS') except those explicitly related to the final stage of descent-increase. This restriction relate to only the two parameters following of the solver MUMPS : `POSTTRAITEMENTS` and `RESI_RELA`. In parallel, one particularly advises the parameter setting  $7\text{Afin}^7 = \text{'MUMPS'}$  and `RENUM = 'QAMD'`. For

<sup>6</sup> to save time computation, one revalues only for the new discretization, finest. If they

<sup>7</sup> to at least reduce the cost in time of the phase of analysis (sequential) of MUMPS. This parameter setting is done however to the detriment of memory consumption. But this overcost quickly proves compensated by the distribution of the data on the processors which parallelism implies. METHODE

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more details on the solvers, one will be able to consult the document [U4.50.01]. Operand

## 3.11 NIVEAU\_PARALLELISME $\diamond$ NIVEAU

```
_PARALLELISME = "COMPLET" " [DEFAULT ]/"PARTIAL  
" When
```

one deals with problems of sizes **average or large** (> 0.5 M degrees of freedom) and/or that one seeks a good **part of their spectrums** (> 50 modes), the recourse to parallelism gets appreciable gains in time and memory. And this, with a functional behavior and precise details of results unchanged compared to the sequential mode. The natural

independent Nb\_sbande computation division INFO\_MODE (number of sous-bandes=nb\_freq-1 or nb\_mode\_flamb-1), gets a first very effective level of parallelism (in time). It does not impact consumption mémoire<sup>8</sup> which<sup>8</sup>

, like the essence of the cost computation is due to the phase of factorization numérique<sup>9</sup> Etape<sup>9</sup>, if one parallels this stage via MUMPS (METHODE=' MUMPS'), one adds notable gains in time and memory. It is a second level of parallelism activable. With

the value by default of this key word (NIVEAU\_PARALLELISME=' COMPLET'), when computation is parallel, the two levels of parallelism cumulate. As the second (that of the linear solver) is less effective than the first, it starts only if the number of processors allows it (nb\_proc>nb\_sbande) and that if the selected linear solver supports parallelism MPI (SOLVEUR=\_F (METHODE=' MUMPS')). If one

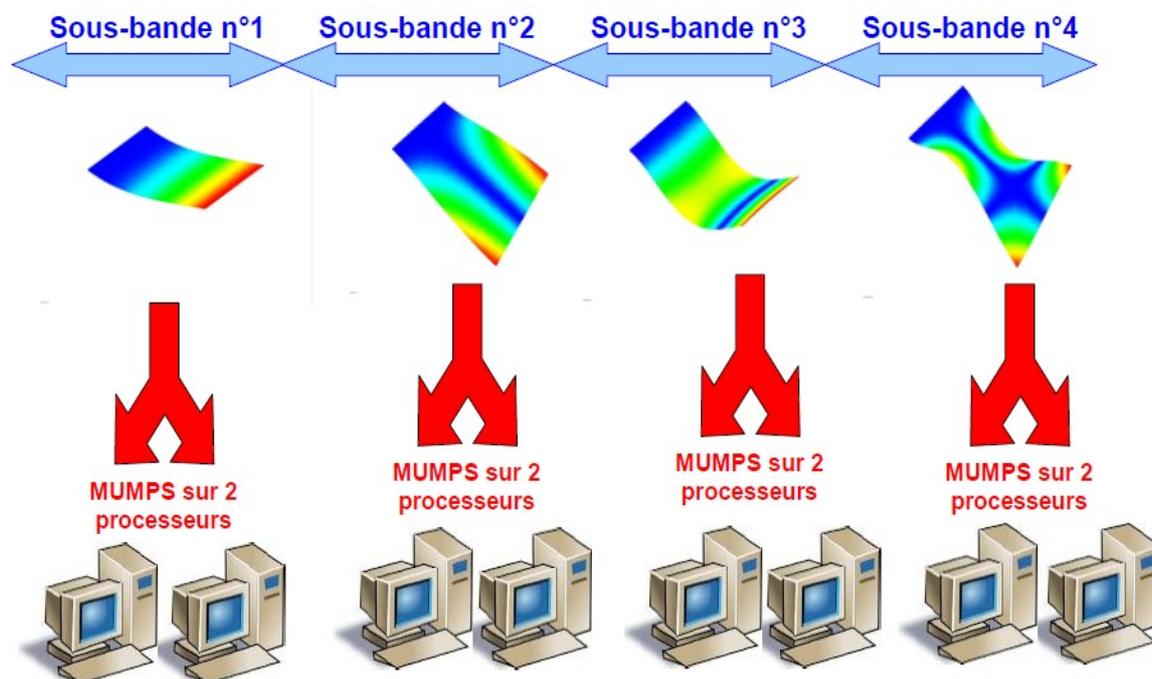
selects the other value of key word (NIVEAU\_PARALLELISME=' PARTIEL'), one benefits only from the parallelism of the linear solver (the second level). That can have interest to test methods or to center the gains on the reduction of the peak report (after having tested the other lever arms proposed in the key word solver ). For

more information on the implementation of parallelism, one will refer to documentation [U2.08 .06] or the dedicated paragraph of documentation [U2.06.01]. Figure

<sup>8</sup> is the case for parallel MACRO\_MODE\_MECA . In addition

<sup>9</sup> of the linear solver who gains the most profit from parallelism. of the linear solver

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3.11-1. Example of distribution of computations of INFO\_MODE on 8 processors with a cutting in 4 frequential sub-bands. Thus

, by activating only the first level of parallelism, a computation cut out in `nb_sbande` and paralleled on `nb_proc = nb_sbande` can gain in time at least a factor  $\text{nb\_sbande} / 2$  (without overcost report and loss of accuracy). If one by means of distributes computation on more processors ( $\text{nb\_proc} > \text{nb\_sbande}$ ) the MUMPS solver (the 2nd level adds some thus), the savings of time will be improved of a factor close to 2 for each  $2 * \text{nb\_sbande}$  processors supplémentaires<sup>10</sup>, with gains in memory being able to go until a factor 211Dans<sup>11</sup>

preserve the parallel effectiveness of computations, one advises: With

- “COMPLET”, to select a number of processors which is a multiple amongst sub-bands. Typically 2,4 or 8. That limits the unbalance of load. With
- “PARTIAL”, to reserve at least 105 degrees of freedom per processor in order to feed the linear solver MUMPS sufficiently. The functional

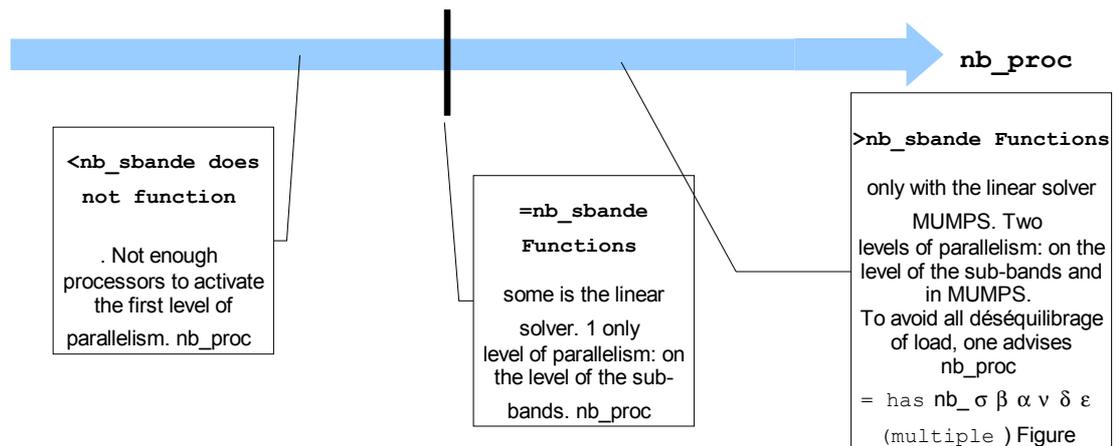
rules are the following ones, by noting `nb_proc` the number of parameterized processors (mitre option `/mpi_nbcpu` of Astk) and `nb_sbande` the number of nonempty sub-bands: With

- `NIVEAU_PARALLELISME='COMPLET'` (default): **very** large saving of time/improvement of the peak RAM report. `nb_proc`

<sup>10</sup> the sufficiently large problems ( $N > 0.5M$ ), the parallel effectiveness of the phase of factorization of MUMPS is often close to 0.5 (especially with a renumerator standard “QAMD” cf §3.10 frustrates). And this

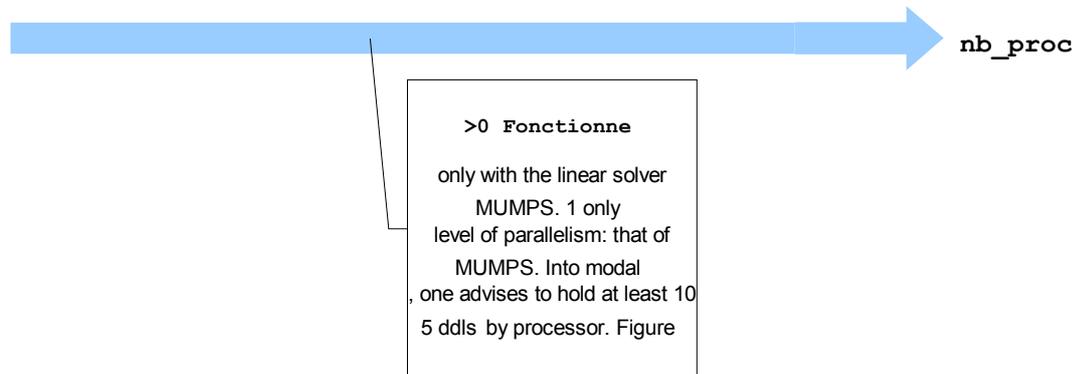
<sup>11</sup> INFO\_MODE, memory consumptions of MUMPS are particularly optimized: operation in IN-CORE does not consume more memory than the OUT-OF-CORE (gain x3). This behavior is adapted for this operator. The gains which can get to him parallelism are thus, in proportion, less important. In order to

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### 3.11-2. Perimeter of use with NIVEAU\_PARALLELISME=' COMPLET'. With

- NIVEAU\_PARALLELISME=' PARTIEL': gain moderated in time/important gain on the peak RAM report. nb\_proc



### 3.11-3. Perimeter of use with NIVEAU\_PARALLELISME=' PARTIEL'. Examples

## 4 Example

### 4.1 n°1 Comparison

of two methods **STURM TYPE** and **APM** on the standard **GEP** of **SDLD02** has (for **STURM TYPE** the limits are mentioned in frequency). In the first computation, one to seek to count the number of modes contained in the frequential tape formulates  $[0;5]$  the usual method: **STURM TYPE**. In the second, one makes the same thing with method **APM**, but in the disc centered in the beginning (center=0+0j) and of radius radius = formula  $(2\pi.5)^2$  there is no change of unit with **APM**). The two results are displayed in the message file . f1=5.0

```
nbmod
01 = INFO_MODE (MATR_RIGI=MATASSR, MATR_MASS=MATASSM, TYPE_MODE=' DYNAMIQUE', FREQ=
              (0. , f1), COMPTAGE=_F (METHODE=' STURM'),) w1= (2
*pi*f1) ** 2 nbmod
11 = INFO_MODE (MATR_RIGI=MATASSR, MATR_MASS=MATASSM, TYPE_MODE=' MODE_COMPLEXE',
              TYPE_
              CONTOUR=' CERCLE', CENTRE_CONTOUR=0.0+0.0j, RADIUS
              CONTOUR=w1, COMPTAGE=_F (METHODE=' APM'),) With
```

INFO= 1, that causes the displays following in the message file :

```
VERIFICATION
  OF the FREQUENCY SPECTRUM (METHODE OF STURM TYPE) NOT OF
  FREQUENCY IN the TAPE (0.000E+00, 5.000E+00) .....
(METHODE
APM) FOR the 3 FOLLOWING LEVELS OF DISCRETIZATION ---
 20 --- 40 --- 80 --- NUMBER OF VALUES
PROPER DETECTEES ---
 0 --- 0 --- 0 --- (METHODE
APM) CONVERGENCE OF THE HEURISTICS
-----
VERIFICATION
  OF the FREQUENCY SPECTRUM (METHODE OF the ARGUMENT the MAIN THING) NOT OF
  FREQUENCY IN LE DISQUE CENTER IN (0.000E+00, 0.000E+00) AND OF
  RADIUS 9.870 E+02 Here,
```

the method of Sturm type required only two factorizations. Method **APM** converged immediately with the first iteration. But this one required factorizations  $20 + 40 + 80 = 140$ . The enumeration of eigenvalues in the complex plane has a price (which one does not manage for time to reduce)! The number

of the eigenfrequencies (0 in this case) as well as the search criteria are saved in an array . The printing, by **IMPR\_TABLE**, of concepts **NBMOD 01** and **NBMOD 11** products by **INFO\_MODE** in the preceding example shows the following composition: nbmod

```
01 FREQ_MIN
FREQ_MAX      NB_MODE      0.00000
E+00 5.00000  E+00 0...    nbmod

11 CENTER
R CENTER      I RADIUS     NB_MODE      0.00000
E+00 0.00000  E+00 9.86960  E+02 0 When
```

**INFO\_MODE** is called with option **TYPE\_MODE=' MODE\_FLAMB'**, the produced arrays contain three columns: **NB\_MODE** (the number of eigenvalues) like **CHAR\_CRIT\_MIN** and **CHAR\_CRIT\_MAX**, the search criteria for the dynamic problems with linear buckling. Example

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## 4.2 n°2 Enumeration

concerning the QEP of SDLL123 A. This time, only method APM proves to be licit. One counts the number of modes contained in the circle centered in the beginning () and of  $centre=0+0j$  radius formulates  $rayon=124 \times 2\pi$

```
. *2.*pi nbmod
4=INFO_MODE (MATR_RIGI=RIGIDITE, MATR_MASS=MASSE, MATR_C=GYOM, TYPE_MODE=' MODE_COMPLEXE',
TYPE_
          CONTOUR=' CERCLE', CENTRE_CONTOUR=0.0+0.0j, RADIUS
          _CONTOUR=f1, COMPTAGE=_F (METHODE=' APM',),) In INFO
```

= 1 that causes the displays following in the message file : (METHODE

```
APM) FOR THE 3 FOLLOWING LEVELS OF DISCRETIZATION ---
20 --- 40 --- 80 --- NUMBER OF VALUES
PROPER DETECTEES ---
4 --- 4 --- 4 --- (METHODE
APM) CONVERGENCE OF THE HEURISTICS
-----
VERIFICATION
OF the FREQUENCY SPECTRUM (METHODE OF the ARGUMENT the MAIN THING) LE
FREQUENCY
many IN LE DISQUE CENTER IN (0.000E+00, 0.000E+00) AND OF
RADIUS 7.791 E+02 EAST 4 And
```

the printing of the array produced (nbmod4) by IMPR\_TABLE gives : CENTER

```
R CENTER I RADIUS NB_MODE 0.00000
E+00 0.00000 E+00 7.79115 E+02 4
```