# Package ‘m2r’

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**Type** Package

**Title** Interface to 'Macaulay2'

**Version** 1.0.2

**Maintainer** David Kahle <david@kahle.io>

**Description** Persistent interface to 'Macaulay2' <http://www.math.uiuc.edu/Macaulay2/>
and front-end tools facilitating its use in the 'R' ecosystem. For details see
Kahle et. al. (2020) <doi:10.18637/jss.v093.i09>.

**License** GPL-2

**LazyData** TRUE

**Depends** mpoly (>= 1.0.5)

**Imports** stringr, memoise, gmp, usethis, Rcpp

**SystemRequirements** Macaulay2 <http://www.math.uiuc.edu/Macaulay2/>

**URL** https://github.com/coneill-math/m2r

**BugReports** https://github.com/coneill-math/m2r/issues

**Suggests** knitr, rmarkdown, microbenchmark, testthat, R.rsp

**RoxygenNote** 7.1.0

**LinkingTo** Rcpp

**VignetteBuilder** R.rsp

**Encoding** UTF-8

**NeedsCompilation** yes

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**Repository** CRAN

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# R topics documented:



---

`enter_m2` *Enter a Macaulay2 session*

---

### Description

Enter a Macaulay2 session

### Usage

```
enter_m2(port = 27436L, timeout = 10)
```

### Arguments

| | |
|---|---|
| `port` | port for Macaulay2 socket |
| `timeout` | number of seconds before aborting |

### Value

`TRUE` invisibly

### Examples

```
## Not run:  requires Macaulay2 be installed and an interactive session

enter_m2()

# m2 code below
1 + 1
a = 1
a
R = QQ[t,x,y,z]
I = ideal(t^4  -  x, t^3  -  y, t^2  -  z)
gens gb I
exit

# back in R, the variable persists using m2()
m2("a")
m2("I")


# we can also define variables in R that persist in m2
m2("b = 5")

enter_m2()
b
exit


## End(Not run)
```

---

## factor_n — *Factor an integer into primes*

---

### Description

Factor an integer into primes

### Usage

```
factor_n(n, code = FALSE, ...)

factor_n.(n, code = FALSE, ...)
```

### Arguments

| | |
|---|---|
| n | an integer or a polynomial |
| code | return only the M2 code? (default: FALSE) |
| ... | ... |

## Value

a data frame with integer columns `prime` and `power` or `m2_pointer` referencing the factorization in M2.

## Examples

```
## Not run:  requires Macaulay2

##### basic usage
########################################

2^2 * 3^7 * 5^2 # = 218700
factor_n(218700)
factor_n.(218700)

(df <- factor_n(218700))
df$prime
df$power
str(df)


factor_n(218700, code = TRUE)


##### other options
########################################

(integer_pointer <- m2.("218700"))
m2_name(integer_pointer)
factor_n(integer_pointer, code = TRUE)
factor_n(integer_pointer)



factor_n(3234432540)
factor_n(323443254223453)
factor_n(rpois(1, 1e4))


##### known issues
########################################

# R doesn't handle big ints well. note in the following
# the m2 code number is different than the supplied number
factor_n(32344325422364353453, code = TRUE)

# this can be circumvented by passing a string instead
factor_n("32344325422364353453", code = TRUE)

# but if the factors are large, R can't handle the parsing well
factor_n("32344325422364353453")
```

```
# here's a workaround:
factor_pointer <- factor_n.("32344325422364353453")
m2_meta(factor_pointer, "ext_str")
extract_factors <- function(pointer) {
  require(stringr)
  str <- m2_meta(pointer, "ext_str")
  str <- str_sub(str, 19, -2)
  str <- str_extract_all(str, "\\{[0-9]+,[0-9]+\\}")[[1]]
  str <- str_sub(str, 2, -2)
  str <- str_split(str, ",")
  df <- as.data.frame(t(simplify2array(str)))
  names(df) <- c("prime", "power")
  df
}
(df <- extract_factors(factor_pointer))


# using gmp (currently broken)
# factor_n("32344325422364353453", gmp = TRUE)
m2("11 * 479 * 6138607975396537")
11 * 479 * 6138607975396537


## End(Not run)
```

---

`factor_poly` *Factor a polynomial*

---

### Description

Factor a polynomial

### Usage

```
factor_poly(mpoly, code = FALSE)

factor_poly.(mpoly, code = FALSE, ...)
```

### Arguments

| | |
|---|---|
| `mpoly` | a character parseable by `mp()`, an `mpoly` object, or a pointer to a polynomial in M2 |
| `code` | return only the M2 code? (default: `FALSE`) |
| `...` | ... |

### Value

a named list with elements `factor` (an `mpolyList` object) and `power`, an integer vector

### Examples

```
## Not run:  requires Macaulay2 be installed and an interactive session

##### basic usage
########################################

ring("x", "y", coefring = "QQ")
factor_poly("x^4 - y^4")

# reference function
factor_poly.("x^4 - y^4")


##### different inputs
########################################

# factor_poly accepts mpoly objects:
# remember you must create the ring first!
(p <- mp("x^4 - y^4"))
factor_poly.(p)
factor_poly(p)
mp("(x-y) (x+y) (x^2+y^2)")



##### other examples
########################################

ring("x","y", "z", coefring = "QQ")
(p <- mp("(x^2 - y) (x^2 + y) (x + y)^2 (x - z)^2"))
factor_poly.(p)
factor_poly(p)

(p <- mp("(x-1)^3 (y-1)^3"))
factor_poly.(p)
factor_poly(p)


## End(Not run)
```

---

gb *Compute a Grobner basis with Macaulay2*

---

### Description

Compute a Grobner basis with Macaulay2

## Usage

```
gb(..., control = list(), raw_chars = FALSE, code = FALSE)

gb.(..., control = list(), raw_chars = FALSE, code = FALSE)

gb_(x, control = list(), raw_chars = FALSE, code = FALSE, ...)

gb_.(x, control = list(), raw_chars = FALSE, code = FALSE, ...)
```

## Arguments

| | |
|---|---|
| `...` | ... |
| `control` | a list of options, see examples |
| `raw_chars` | if `TRUE`, the character vector will not be parsed by `mp()`, saving time (default: `FALSE`). the down-side is that the strings must be formated for M2 use directly, as opposed to for `mp()`. (e.g. `"x*y+3"` instead of `"x y + 3"`) |
| `code` | return only the M2 code? (default: `FALSE`) |
| `x` | a character vector of polynomials to be parsed by `mp()`, a `mpolyList` object, an `ideal()` or pointer to an ideal |

## Details

gb uses nonstandard evaluation; gb_ is the standard evaluation equivalent.

## Value

an `mpolyList` object of class `m2_grobner_basis` or a `m2_grobner_basis_pointer` pointing to the same. See `mpolyList()`.

## See Also

`mp()`, `use_ring()`

## Examples

```
## Not run:  requires Macaulay2


##### basic usage
########################################

# the last ring evaluated is the one used in the computation
ring("t","x","y","z", coefring = "QQ")
gb("t^4 - x", "t^3 - y", "t^2 - z")

# here's the code it's running in M2
gb("t^4 - x", "t^3 - y", "t^2 - z", code = TRUE)
```

```
##### different versions of gb
########################################

# standard evaluation version
poly_chars <- c("t^4 - x", "t^3 - y", "t^2 - z")
gb_(poly_chars)

# reference nonstandard evaluation version
gb.("t^4 - x", "t^3 - y", "t^2 - z")

# reference standard evaluation version
gb_.(poly_chars)



##### different inputs to gb
########################################

# ideals can be passed to gb
I <- ideal("t^4 - x", "t^3 - y", "t^2 - z")
gb_(I)

# note that gb() works here, too, since there is only one input
gb(I)

# ideal pointers can be passed to gb
I. <- ideal.("t^4 - x", "t^3 - y", "t^2 - z")
gb_(I.)

# setting raw_chars is a bit faster, because it doesn't use ideal()
gb("t^4 - x", "t^3 - y", "t^2 - z", raw_chars = TRUE, code = TRUE)
gb("t^4 - x", "t^3 - y", "t^2 - z", raw_chars = TRUE)



##### more advanced usage
########################################

# the control argument accepts a named list with additional
# options
gb_(
  c("t^4 - x", "t^3 - y", "t^2 - z"),
  control = list(StopWithMinimalGenerators = TRUE),
  code = TRUE
)

gb_(
  c("t^4 - x", "t^3 - y", "t^2 - z"),
  control = list(StopWithMinimalGenerators = TRUE)
)
```

```
##### potential issues
########################################

# when specifying raw_chars, be sure to add asterisks
# between variables to create monomials; that's the M2 way
ring("x", "y", "z", coefring = "QQ")
gb("x y", "x z", "x", raw_chars = TRUE, code = TRUE) # errors without code = TRUE
gb("x*y", "x*z", "x", raw_chars = TRUE, code = TRUE) # correct way
gb("x*y", "x*z", "x", raw_chars = TRUE)

## End(Not run)
```

---

`ideal` *Create a new ideal in Macaulay2*

---

## Description

Create a new ideal in Macaulay2

## Usage

```
ideal(..., raw_chars = FALSE, code = FALSE)

ideal.(..., raw_chars = FALSE, code = FALSE)

ideal_(x, raw_chars = FALSE, code = FALSE, ...)

ideal_.(x, raw_chars = FALSE, code = FALSE, ...)

## S3 method for class 'm2_ideal'
print(x, ...)

## S3 method for class 'm2_ideal_list'
print(x, ...)

radical(ideal, ring, code = FALSE, ...)

radical.(ideal, ring, code = FALSE, ...)
```

```
saturate(I, J, code = FALSE, ...)

saturate.(I, J, code = FALSE, ...)

quotient(I, J, code = FALSE, ...)

quotient.(I, J, code = FALSE, ...)

primary_decomposition(ideal, code = FALSE, ...)

primary_decomposition.(ideal, code = FALSE, ...)

dimension(ideal, code = FALSE, ...)

## S3 method for class 'm2_ideal'
e1 + e2

## S3 method for class 'm2_ideal'
e1 * e2

## S3 method for class 'm2_ideal'
e1 == e2

## S3 method for class 'm2_ideal'
e1 ^ e2
```

## Arguments

| | |
|---|---|
| `...` | ... |
| `raw_chars` | if `TRUE`, the character vector will not be parsed by `mp()`, saving time (default: `FALSE`). the down-side is that the strings must be formated for M2 use directly, as opposed to for `mp()`. (e.g. `"x*y+3"` instead of `"x y + 3"`) |
| `code` | return only the M2 code? (default: `FALSE`) |
| `x` | a listing of polynomials. several formats are accepted, see examples. |
| `ideal` | an ideal object of class `m2_ideal` or `m2_ideal_pointer` |
| `ring` | the referent ring in Macaulay2 |
| `I, J` | ideals or objects parsable into ideals |
| `e1, e2` | ideals for arithmetic |

## Value

a reference to a Macaulay2 ideal

## Examples

```
## Not run:  requires Macaulay2


##### basic usage
########################################

ring("x", "y", coefring = "QQ")
ideal("x + y", "x^2 + y^2")



##### different versions of gb
########################################

# standard evaluation version
poly_chars <- c("x + y", "x^2 + y^2")
ideal_(poly_chars)

# reference nonstandard evaluation version
ideal.("x + y", "x^2 + y^2")

# reference standard evaluation version
ideal_.(poly_chars)



##### different inputs to gb
########################################

ideal_(   c("x + y", "x^2 + y^2") )
ideal_(mp(c("x + y", "x^2 + y^2")))
ideal_(list("x + y", "x^2 + y^2") )



##### predicate functions
########################################

I  <- ideal ("x + y", "x^2 + y^2")
I. <- ideal.("x + y", "x^2 + y^2")
is.m2_ideal(I)
is.m2_ideal(I.)
is.m2_ideal_pointer(I)
is.m2_ideal_pointer(I.)



##### ideal radical
########################################

I <- ideal("(x^2 + 1)^2 y", "y + 1")
radical(I)
radical.(I)
```

```
##### ideal dimension
########################################

I <- ideal_(c("(x^2 + 1)^2 y", "y + 1"))
dimension(I)

# dimension of a line
ring("x", "y", coefring = "QQ")
I <- ideal("y - (x+1)")
dimension(I)

# dimension of a plane
ring("x", "y", "z", coefring = "QQ")
I <- ideal("z - (x+y+1)")
dimension(I)



##### ideal quotients and saturation
########################################

ring("x", "y", "z", coefring = "QQ")
(I <- ideal("x^2", "y^4", "z + 1"))
(J <- ideal("x^6"))

quotient(I, J)
quotient.(I, J)

saturate(I)
saturate.(I)
saturate(I, J)
saturate(I, mp("x"))
saturate(I, "x")


ring("x", "y", coefring = "QQ")
saturate(ideal("x y"), "x^2")

# saturation removes parts of varieties
# solution over R is x = -1, 0, 1
ring("x", coefring = "QQ")
I <- ideal("(x-1) x (x+1)")
saturate(I, "x") # remove x = 0 from solution
ideal("(x-1) (x+1)")



##### primary decomposition
########################################
```

```
ring("x", "y", "z", coefring = "QQ")
I <- ideal("(x^2 + 1) (x^2 + 2)", "y + 1")
primary_decomposition(I)
primary_decomposition.(I)

I <- ideal("x (x + 1)", "y")
primary_decomposition(I)

# variety = z axis union x-y plane
(I <- ideal("x z", "y z"))
dimension(I) # =  max dimension of irreducible components
(Is <- primary_decomposition(I))
dimension(Is)



##### ideal arithmetic
########################################

ring("x", "y", "z", coefring = "RR")

# sums (cox et al., 184)
(I <- ideal("x^2 + y"))
(J <- ideal("z"))
I + J

# products (cox et al., 185)
(I <- ideal("x", "y"))
(J <- ideal("z"))
I * J

# equality
(I <- ideal("x", "y"))
(J <- ideal("z"))
I == J
I == I

# powers
(I <- ideal("x", "y"))
I^3


## End(Not run)
```

---

`is` *Macaulay2 object tests*

---

## Description

Predicate functions for Macaulay2 objects.

### Usage

```
is.m2(x)

is.m2_pointer(x)

is.ring(x)

is.m2_polynomialring(x)

is.m2_polynomialring_pointer(x)

is.m2_grobner_basis(x)

is.m2_ideal(x)

is.m2_ideal_pointer(x)

is.m2_ideal_list(x)

is.m2_ideal_list_pointer(x)

is.m2_module(x)

is.m2_option(x)

is.m2_matrix(x)

is.m2_matrix_pointer(x)

is.m2_list(x)

is.m2_array(x)

is.m2_sequence(x)
```

### Arguments

| | |
|---|---|
| `x` | an object |

### Value

logical(1)

### Examples

```
## Not run:  requires Macaulay2

R <- ring(c("x1", "x2", "x3"))
```

```
is.m2(R)
is.ring(R)
is.ring(10)
is.ring(mp("x+1"))


## End(Not run)
```

LLL *LLL algorithm*

## Description

Macaulay2's implementation of the LLL algorithm. This implementation is still under development and is currently untested.

## Usage

```
LLL(mat, control = list(), code = FALSE)

LLL.(mat, control = list(), code = FALSE)
```

## Arguments

| | |
|---|---|
| `mat` | a matrix (integer entries) |
| `control` | additional arguments to pass to LLL; see examples |
| `code` | return only the M2 code? (default: `FALSE`) |

## Value

an object of class `m2_matrix`

## See Also

`m2_matrix()`

## Examples

```
## Not run:  requires Macaulay2

##### basic usage
########################################

# example 1
M <- matrix(c(
  1, 1, 1, 1,
  2, 0, 3, 4,
  1, 0, 0, 0,
```

```
  0, 1, 0, 0,
  0, 0, 1, 0,
  0, 0, 0, 1
), nrow = 6, byrow = TRUE)

LLL(M)




# example 2 (wikipedia)
M <- matrix(c(
  1, -1, 3,
  1,  0, 5,
  1,  2, 6
), nrow = 3, byrow = TRUE)

LLL(M)


##### control
########################################

M <- matrix(c(
  1, 1, 1, 1,
  2, 0, 3, 4,
  1, 0, 0, 0,
  0, 1, 0, 0,
  0, 0, 1, 0,
  0, 0, 0, 1
), nrow = 6, byrow = TRUE)

LLL(M, code = TRUE)
LLL(M, control = list(Strategy = "NTL"), code = TRUE)
LLL(M, control = list(Strategy = c("BKZ", "RealFP")), code = TRUE)

LLL(M)
LLL(M, control = list(Strategy = "NTL"))
LLL(M, control = list(Strategy = c("BKZ", "RealFP")))
LLL(M, control = list(Strategy = c("BKZ", "RealQP")))



# method timings with microbenchmark.  note they are roughly the same
# for this example matrix
microbenchmark::microbenchmark(
  "NTL" = LLL(M, control = list(Strategy = "NTL")),
  "BKZ_RealFP" = LLL(M, control = list(Strategy = c("BKZ", "RealFP"))),
  "BKZ_RealQP" = LLL(M, control = list(Strategy = c("BKZ", "RealQP"))),
  "BKZ_RealRR" = LLL(M, control = list(Strategy = c("BKZ", "RealRR")))
)
```

```
##### additional examples
########################################

LLL.(M)
LLL(M, code = TRUE)




## End(Not run)
```

---

m2r *Macaulay2 in R*

---

## Description

m2r provides a persistent interface to Macaulay2 (http://www.math.uiuc.edu/Macaulay2/) and front-end tools facilitating its use in the R ecosystem. For details, see vignette("m2r").

## References

D. Kahle, C. O'Neill, and J. Sommars (2020). "A Computer Algebra System for R: Macaulay2 and the m2r Package." Journal of Statistical Software, 93(9):1-31.

---

m2_call *Call and reset a Macaulay2 process*

---

## Description

Call and reset a Macaulay2 process

## Usage

```
m2r_version_number()

m2r_cloud_url()

has_m2_connection()

start_m2(
  port = 27436L,
  timeout = 10,
  attempts = 10,
  cloud = FALSE,
```

```
  hostname = m2r_cloud_url()
)

stop_m2()

reset_m2(
  port = 27436L,
  timeout = 10,
  attempts = 10,
  hostname = "ec2-52-10-66-241.us-west-2.compute.amazonaws.com"
)

m2(code, timeout = -1)

m2.(code, timeout = -1)

## S3 method for class 'm2_pointer'
print(x, ...)
```

## Arguments

| | |
|---|---|
| `port` | port for Macaulay2 socket |
| `timeout` | number of seconds before aborting |
| `attempts` | numer of times to try to make connection |
| `cloud` | use a cloud? |
| `hostname` | the remote host to connect to; defaults to the Amazon EC2 instance |
| `code` | Macaulay2 code |
| `x` | formal argument for print method |
| `...` | ... |

## Value

m2 return value

## Examples

```
## Not run:  requires Macaulay2

m2("1 + 1")
m2.("1 + 1")

m2("factor 32004")

# run a chunk of m2 code, only pulling the end value back into R
m2("
  R = QQ[a..d]
  I = ideal(a^3-b^2*c, b*c^2-c*d^2, c^3)
```

```
  G = gens gb I
")

# illustrate the persistent connection
m2("a = 1 + 1")
m2("a")
reset_m2()
m2("a")


# forcing a cloud start
if(has_m2_connection()) stop_m2()
start_m2(cloud = TRUE)
m2("1 + 1")
stop_m2()



m2.("peek(QQ[x,y,z])")
m2("peek(QQ[x,y,z])")

# m2 returns in its ext_str position the result of running
# toExternalString on the return value of the chunk of code
# you run. in principle, toExternalString provides the code
# needed to recreate the m2 object of interest. however,
# does not work for all objects representable in the m2 language.
# in particular, mutable objects are not supported.
# this is what happens when you look at those:
m2.("new MutableList from {1,2,3}")
m2("new MutableList from {1,2,3}")


## End(Not run)
```

---

m2_matrix *Create a new matrix in Macaulay2*

---

## Description

Create a new matrix in Macaulay2

## Usage

```
m2_matrix(mat, ring, name, code = FALSE)

m2_matrix.(mat, ring, name, code = FALSE)

m2_numrows(x, code = FALSE, ...)

m2_numcols(x, code = FALSE, ...)
```

```
m2_length(x, code = FALSE, ...)

## S3 method for class 'm2_matrix'
print(x, ...)

## S3 method for class 'm2_image'
print(x, ...)

m2_kernel(mat, name, code = FALSE)

m2_kernel.(mat, name, code = FALSE)
```

## Arguments

| | |
|---|---|
| mat | a matrix |
| ring | a ring containing the matrix entries |
| name | the m2_name of the object, which is it's name on the M2 side |
| code | return only the M2 code? (default: FALSE) |
| x | formal argument for print method |
| ... | ... |

## Value

an object of class m2_matrix

## Examples

```
## Not run:  requires Macaulay2

##### basic usage
########################################

(mat <- m2_matrix(matrix(c(1,2,3,4,5,6), nrow = 3, ncol = 2)))
m2_matrix(matrix(c(1,2,3,4,5,6), nrow = 3, ncol = 2))

m2_name(mat)
m2(m2_name(mat))
m2(sprintf("class(%s)", m2_name(mat)))
(mat <- m2_matrix.(matrix(c(1,2,3,4,5,6), nrow = 3, ncol = 2)))

##### known issues
########################################

ring("x", "y", "z", coefring = "QQ")
(mat <- matrix(mp(c("x","y","x+y","y-2","x-3","y-z")), nrow = 2, ncol = 3))
m2_matrix(mat, code = TRUE)
m2_matrix(mat)
```

```
# the above is an mpoly problem, not a m2r problem
# mpoly does not have a data structure for matrices (as of 12/2016)

mat_chars <- sapply(m2_matrix(mat), print, silent = TRUE)
dim(mat_chars) <- c(2, 3)
mat_chars


m2_numrows(mat)
m2_numcols(mat)
m2_parse(mat)

(mat <- m2_matrix(matrix(c(1,2),nrow=1)))
m2_kernel(mat)


## End(Not run)
```

---

`m2_parser` *Convert a M2 object into an R object*

---

## Description

Convert a M2 object into an R object

## Usage

```
m2_parse(s)

## S3 method for class 'm2_integer'
print(x, ...)

## S3 method for class 'm2_float'
print(x, ...)

## S3 method for class 'm2_complex'
print(x, ...)

## S3 method for class 'm2_string'
print(x, ...)

## S3 method for class 'm2_boolean'
print(x, ...)

## S3 method for class 'm2_list'
print(x, ...)

## S3 method for class 'm2_array'
```

```
print(x, ...)

## S3 method for class 'm2_sequence'
print(x, ...)

## S3 method for class 'm2_symbol'
print(x, ...)

## S3 method for class 'm2_option'
print(x, ...)

## S3 method for class 'm2_hashtable'
print(x, ...)

## S3 method for class 'm2_module'
print(x, ...)

m2_toggle_gmp()

get_m2_gmp()
```

### Arguments

| | |
|---|---|
| `s` | a character(1), typically the result of running toExternalString on an M2 object |
| `x` | an object to be printed |
| `...` | ... |

### Value

an R object

### References

D. Kahle, C. O'Neill, and J. Sommars (2020). "A Computer Algebra System for R: Macaulay2 and the m2r Package." Journal of Statistical Software, 93(9):1-31.

### Examples

```
## Not run:  requires Macaulay2

m2("1+1")
m2.("1+1")
m2_parse(m2.("1+1"))

m2("QQ[x,y]")
m2.("QQ[x,y]")
m2_parse(m2.("QQ[x,y]"))

get_m2_gmp()
```

```
m2("3/2") %>% m2_parse()
m2_toggle_gmp() # gmp on
m2("3/2") %>% m2_parse()
m2("6/4") %>% m2_parse()
m2("3345234524352435432/223454325235432524352433245") %>% m2_parse()
m2_toggle_gmp() # gmp off



m2("50!") %>% m2_parse()
m2_toggle_gmp() # gmp on
m2("50!") %>% m2_parse()
m2_toggle_gmp() # gmp off


## End(Not run)
```

---

m2_path *Set path to Macaulay2 (M2)*

---

### Description

These are helper functions that deal with pathing to Macaulay2 and asking if it is present. When the Macaulay2 package is loaded it attempts to find the Macaulay2 executable by looking for an environment variable indicating where it is, i.e. its path as specified in your .Renviron file.

### Usage

```
set_m2_path(path = NULL)

get_m2_path()

get_m2_connection()

get_m2_con()

get_m2_procid()

get_m2_port()
```

### Arguments

| | |
|---|---|
| path | A character string, the path to M2 |

### Details

For easiest use, you'll want to specify the path the Macaulay2 executable in your ~/.Renviron file. It should look something like

```
M2=/Applications/Macaulay2-1.10/bin
```

You can set this permanently with `edit_r_environ()`. Note that absolute paths should be specified, not relative paths, e.g. don't use ~/path/to/exe.

You can change this for the current session using `set_m2_path()`, which accepts a character string or, if missing, uses `file.choose()` to let you interactively; you just select an arbitrary executable.

On Windows, m2r just defaults to the cloud implementation. Local M2 instances are not currently supported on Windows.

## Value

An invisible character string, the path found. More importantly, the function has the side effect of setting the global m2r option "m2_path"

## Author(s)

David Kahle <david@kahle.com>

## Examples

```
## Not run:  requires Macaulay2


getOption("m2r")
get_m2_path()
set_m2_path()


## each of these functions can be used statically as well
(m2_path <- get_m2_path())
set_m2_path("/path/to/m2/directory")
get_m2_path()
set_m2_path(m2_path) # undoes example


# if you'd like to use the cloud, after you library(m2r)
# and before you use m2() type
set_m2_path(NULL)

# alternatively, if you have already been using m2, do:
stop_m2()
set_m2_path(NULL)
m2("1+1")



## End(Not run)
```

## m2_utility — *Utility tools for M2*

### Description

Utility tools for M2

### Usage

```
m2_name(x)

m2_name(x) <- value

m2_meta(x, m2_attr)

m2_meta(x, m2_attr) <- value

m2_structure(x = NA, m2_name, m2_class, m2_meta, base_class)

m2_exists(name)

m2_ls(all.names = FALSE)

m2_rm(name)

m2_getwd()
```

### Arguments

| | |
|---|---|
| `x` | an object of class `m2` |
| `value` | the value to assign |
| `m2_attr` | the name of an M2 attribute |
| `m2_name` | `m2_name` M2 attribute |
| `m2_class` | `m2_class` M2 attribute |
| `m2_meta` | `m2_meta` M2 attribute |
| `base_class` | a base class; an R class to use for dispatching if there is no relevant method for the other classes (e.g. `m2`) |
| `name` | a string; the name of a M2 object |
| `all.names` | if `TRUE`, all registered Macaulay2 variables, including ones internally used by m2r, will be returned |

## Examples

```
## Not run:  requires Macaulay2

m2("a = 5")
m2_ls()
m2_exists("a")
m2("b = 1")
m2_exists(c("a","b","c"))

m2_getwd()

x <- 1
class(x) <- "m2"
attr(x, "m2_meta") <- list(a = 1, b = 2)
m2_meta(x)
m2_meta(x, "b")
m2_meta(x, "b") <- 5
m2_meta(x, "b")

# R <- ring(c("x1", "x2", "x3"))
# m2_name(R)
# m2(sprintf("class %s", m2_name(R)))
# m2_ls()
# m2_rm(m2_name(R))
# m2_ls()
# m2(paste("class", m2_name(R)))

m2_ls()
m2_ls(all.names = TRUE)



## End(Not run)
```

---

phc *PHCpack*

---

## Description

Call PHCpack to solve a zero-dimensional system

## Usage

```
solve_system(mpolyList)

solve_system.(mpolyList)

mixed_volume(mpolyList)
```

### Arguments

mpolyList An mpolyList object

### Details

Note that `solve_system()` doesn't take in an input ring because the solver only works over the complex numbers.

### Value

(currently) the output of an m2() call (string?)

### Examples

```
## Not run:  requires Macaulay2

# for this to work, you need to have modified your
# init-PHCpack.m2 file instead of changing your .bashrc
# file to establish the path of phc
# (**clarify**, maybe checkout algstat::polySolve)

(mpolyList <- mp(c("t^4 - x", "t^3 - y", "t^2 - z", "x+y+z")))
solve_system(mpolyList)
mixed_volume(mpolyList)


## End(Not run)
```

---

## ring *Create a new ring in Macaulay2*

---

### Description

Create a new ring in Macaulay2

### Usage

```
ring(..., coefring = m2_coefrings(), order = m2_termorders(), code = FALSE)

ring.(..., coefring = m2_coefrings(), order = m2_termorders(), code = FALSE)

ring_(
  vars,
  coefring = m2_coefrings(),
  order = m2_termorders(),
  code = FALSE,
  ...
```

```
)

ring_.(
  vars,
  coefring = m2_coefrings(),
  order = m2_termorders(),
  code = FALSE,
  ...
)

m2_coefrings()

m2_termorders()

## S3 method for class 'm2_polynomialring'
print(x, ...)
```

## Arguments

| | |
|---|---|
| `...` | ... |
| `coefring` | coefficient ring (default: `"CC"`) |
| `order` | a term order (default: `"grevlex"`) |
| `code` | return only the M2 code? (default: `FALSE`) |
| `vars` | vector of variable names |
| `x` | formal argument for print method |

## Value

a reference to a Macaulay2 ring

## Examples

```
## Not run:  requires Macaulay2

##### basic usage
########################################

ring("x", "y")
ring("x", "y", coefring = "QQ")


##### standard evaluation
########################################

ring_(c("x", "y"))
ring_(c("x", "y"), code = TRUE)

(myring <- ring_(c("x1","x2","x3","y"), coefring = "QQ", order = "lex"))
```

```
m2_name(myring)
m2_meta(myring, "vars")
m2_meta(myring, "coefring")
m2_meta(myring, "order")

##### other options
########################################

ring_.(c("x", "y"))
ring_.(c("x", "y"), code = TRUE)


## End(Not run)
```

---

`snf` *Smith normal form*

---

## Description

For an integer matrix M, this computes the matrices D, P, and Q such that $D = PMQ$, which can be seen as an analogue of the singular value decomposition. All are integer matrices, and P and Q are unimodular (have determinants +- 1).

## Usage

```
snf(mat, code = FALSE)

snf.(mat, code = FALSE)
```

## Arguments

| | |
|---|---|
| `mat` | a matrix (integer entries) |
| `code` | return only the M2 code? (default: `FALSE`) |

## Value

a list of `m2_matrix` objects with names `D`, `P`, and `Q`

## See Also

`m2_matrix()`

## Examples

```
## Not run:  requires Macaulay2

##### basic usage
########################################

M <- matrix(c(
   2,  4,   4,
  -6,  6,  12,
  10, -4, -16
), nrow = 3, byrow = TRUE)

snf(M)

(mats <- snf(M))
P <- mats$P; D <- mats$D; Q <- mats$Q

P %*% M %*% Q                # = D
solve(P) %*% D %*% solve(Q)  # = M

det(P)
det(Q)


M <- matrix(c(
     1,    2,    3,
     1,   34,   45,
  2213, 1123, 6543,
     0,    0,    0
), nrow = 4, byrow = TRUE)
(mats <- snf(M))
P <- mats$P; D <- mats$D; Q <- mats$Q
P %*% M %*% Q                # = D



##### understanding lattices
########################################




# cols of m generate the lattice L
M <- matrix(c(2,-1,1,3), nrow = 2)
row.names(M) <- c("x", "y")
M

# plot lattice
df <- expand.grid(x = -20:20, y = -20:20)
pts <- t(apply(df, 1, function(v) M %*% v))
w <- c(-15, 15)
```

```
plot(pts, xlim = w, ylim = w)

# decompose m
(mats <- snf(M))
P <- mats$P; D <- mats$D; Q <- mats$Q

# PMQ = D, the columns of MQ = P^(-1) D  are a simpler basis of
# the lattice generated by (the cols of) M
(basis <- solve(P) %*% D)

# plot lattice generated by new basis
pts2 <- t(apply(df, 1, function(v) basis %*% v))
points(pts2, pch = "*", col = "red")



##### other options
########################################

snf.(M)
snf(M, code = TRUE)





## End(Not run)
```

---

`str_m2` *Give the structure of a Macaulay2 ring*

---

## Description

Give the structure of a Macaulay2 ring

## Usage

```
str_m2(object, ...)
```

## Arguments

| | |
|---|---|
| `object` | An `m2` object |
| `...` | ... |

## Value

Invisible the object passed in.

## Examples

```
## Not run:  requires Macaulay2

a <- m2("1")

R <- ring(c("x1", "x2", "x3"))
str_m2(R)
str_m2.default(R)


## End(Not run)
```

---

use_ring *Set Macaulay2 ring*

---

## Description

`use_ring()` sets the default referent ring on the Macaulay2 side using the `use` function.

## Usage

```
use_ring(ring)
```

## Arguments

| | |
|---|---|
| `ring` | a `m2_ring` (see `ring()`), `m2_ring_pointer` (see `ring.()`), or a character string containing the name of a ring in Macaulay2 |

## Examples

```
## Not run:  requires Macaulay2


##### basic usage
########################################

ring("x", coefring = "QQ")
factor_poly("x^4 + 1")

QQtxyz <- ring("t","x","y","z", coefring = "QQ")
gb("t^4 - x", "t^3 - y", "t^2 - z")

ring("x", "y", "z", "t", coefring = "QQ")
gb("t^4 - x", "t^3 - y", "t^2 - z")

use_ring(QQtxyz)
```

```
gb("t^4 - x", "t^3 - y", "t^2 - z")

## End(Not run)
```

# Index