

# Package ‘rARPACK’

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**Type** Package

**Title** Solvers for Large Scale Eigenvalue and SVD Problems

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**Description** Previously an R wrapper of the 'ARPACK' library <<http://www.caam.rice.edu/software/ARPACK/>>, and now a shell of the R package 'RSpectra', an R interface to the 'Spectra' library <<http://yixuan.cos.name/spectra/>> for solving large scale eigenvalue/vector problems. The current version of 'rARPACK' simply imports and exports the functions provided by 'RSpectra'. New users of 'rARPACK' are advised to switch to the 'RSpectra' package.

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**URL** <https://github.com/yixuan/rARPACK>

**BugReports** <https://github.com/yixuan/rARPACK/issues>

**Imports** RSpectra

**Suggests** Matrix (>= 1.1-0)

**RoxygenNote** 5.0.1

**NeedsCompilation** no

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eigs

*Find a Specified Number of Eigenvalues/vectors for Square Matrix***Description**

This function is a simple wrapper of the `eigs()` function in the **RSpectra** package. Also see the documentation there.

Given an  $n$  by  $n$  matrix  $A$ , function `eigs()` can calculate a limited number of eigenvalues and eigenvectors of  $A$ . Users can specify the selection criteria by argument `which`, e.g., choosing the  $k$  largest or smallest eigenvalues and the corresponding eigenvectors.

Currently `eigs()` supports matrices of the following classes:

<code>matrix</code>	The most commonly used matrix type, defined in <b>base</b> package.
<code>dgeMatrix</code>	General matrix, equivalent to <code>matrix</code> , defined in <b>Matrix</b> package.
<code>dgCMatrix</code>	Column oriented sparse matrix, defined in <b>Matrix</b> package.
<code>dgRMatrix</code>	Row oriented sparse matrix, defined in <b>Matrix</b> package.
<code>dsyMatrix</code>	Symmetrix matrix, defined in <b>Matrix</b> package.
<code>function</code>	Implicitly specify the matrix through a function that has the effect of calculating $f(x) = Ax$ . See section <b>Function Interface</b> for details.

`eigs_sym()` assumes the matrix is symmetric, and only the lower triangle (or upper triangle, which is controlled by the argument `lower`) is used for computation, which guarantees that the eigenvalues and eigenvectors are real, and in some cases reduces the workload. One exception is when  $A$  is a function, in which case the user is responsible for the symmetry of the operator.

`eigs_sym()` supports "matrix", "dgeMatrix", "dgCMatrix", "dgRMatrix" and "function" typed matrices.

**Usage**

```
eigs(A, k, which = "LM", sigma = NULL, opts = list(), ...)
```

```
eigs_sym(A, k, which = "LM", sigma = NULL, opts = list(),
         lower = TRUE, ...)
```

**Arguments**

<code>A</code>	The matrix whose eigenvalues/vectors are to be computed. It can also be a function which receives a vector $x$ and calculates $Ax$ . See section <b>Function Interface</b> for details.
<code>k</code>	Number of eigenvalues requested.
<code>which</code>	Selection criteria. See <b>Details</b> below.
<code>sigma</code>	Shift parameter. See section <b>Shift-And-Invert Mode</b> .
<code>opts</code>	Control parameters related to the computing algorithm. See <b>Details</b> below.
<code>lower</code>	For symmetric matrices, should the lower triangle or upper triangle be used.
<code>...</code>	Additional arguments such as <code>n</code> and <code>args</code> that are related to the Function Interface. See <code>eigs()</code> in the <b>RSpectra</b> package.

**Details**

The `which` argument is a character string that specifies the type of eigenvalues to be computed. Possible values are:

- "LM" The  $k$  eigenvalues with largest magnitude. Here the magnitude means the Euclidean norm of complex numbers.
- "SM" The  $k$  eigenvalues with smallest magnitude.
- "LR" The  $k$  eigenvalues with largest real part.
- "SR" The  $k$  eigenvalues with smallest real part.
- "LI" The  $k$  eigenvalues with largest imaginary part.
- "SI" The  $k$  eigenvalues with smallest imaginary part.
- "LA" The  $k$  largest (algebraic) eigenvalues, considering any negative sign.
- "SA" The  $k$  smallest (algebraic) eigenvalues, considering any negative sign.
- "BE" Compute  $k$  eigenvalues, half from each end of the spectrum. When  $k$  is odd, compute more from the high and then from the low end.

`eigs()` with matrix type "matrix", "dgeMatrix", "dgCMatrix" and "dgRMatrix" can use "LM", "SM", "LR", "SR", "LI" and "SI".

`eigs_sym()`, and `eigs()` with matrix type "dsyMatrix" can use "LM", "SM", "LA", "SA" and "BE".

The `opts` argument is a list that can supply any of the following parameters:

`ncv` Number of Lanczos basis vectors to use. More vectors will result in faster convergence, but with greater memory use. For general matrix, `ncv` must satisfy  $k + 2 \leq ncv \leq n$ , and for symmetric matrix, the constraint is  $k < ncv \leq n$ . Default is  $\min(n, \max(2*k+1, 20))$ .

`tol` Precision parameter. Default is  $1e-10$ .

`maxitr` Maximum number of iterations. Default is 1000.

`retvec` Whether to compute eigenvectors. If FALSE, only calculate and return eigenvalues.

**Value**

A list of converged eigenvalues and eigenvectors.

- `values` Computed eigenvalues.
- `vectors` Computed eigenvectors. `vectors[, j]` corresponds to `values[j]`.
- `nconv` Number of converged eigenvalues.
- `niter` Number of iterations used in the computation.
- `nops` Number of matrix operations used in the computation.

**Shift-And-Invert Mode**

The `sigma` argument is used in the shift-and-invert mode.

When `sigma` is not NULL, the selection criteria specified by `which` will apply to

$$\frac{1}{\lambda - \sigma}$$

where  $\lambda$ 's are the eigenvalues of  $A$ . This mode is useful when user wants to find eigenvalues closest to a given number. For example, if  $\sigma = 0$ , then `which = "LM"` will select the largest values of  $1/|\lambda|$ ,

which turns out to select eigenvalues of  $A$  that have the smallest magnitude. The result of using `which = "LM"`, `sigma = 0` will be the same as `which = "SM"`, but the former one is preferable in that ARPACK is good at finding large eigenvalues rather than small ones. More explanation of the shift-and-invert mode can be found in the SciPy document, <http://docs.scipy.org/doc/scipy/reference/tutorial/arpack.html>.

### Function Interface

The matrix  $A$  can be specified through a function with the definition

```
function(x, args)
{
  ## should return A %*% x
}
```

which receives a vector  $x$  as an argument and returns a vector of the same length. The function should have the effect of calculating  $Ax$ , and extra arguments can be passed in through the `args` parameter. In `eigs()`, user should also provide the dimension of the implicit matrix through the argument `n`.

### Author(s)

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### See Also

[eigen\(\)](#), [svd\(\)](#), [svds\(\)](#)

### Examples

```
library(Matrix)
n = 20
k = 5

## general matrices have complex eigenvalues
set.seed(111)
A1 = matrix(rnorm(n^2), n) ## class "matrix"
A2 = Matrix(A1)          ## class "dgeMatrix"

eigs(A1, k)
eigs(A2, k, opts = list(retvec = FALSE)) ## eigenvalues only

## sparse matrices
A1[sample(n^2, n^2 / 2)] = 0
A3 = as(A1, "dgCMatrix")
A4 = as(A1, "dgRMatrix")

eigs(A3, k)
eigs(A4, k)
```

```

## function interface
f = function(x, args)
{
  as.numeric(args %**% x)
}
eigs(f, k, n = n, args = A3)

## symmetric matrices have real eigenvalues
A5 = crossprod(A1)
eigs_sym(A5, k)

## find the smallest (in absolute value) k eigenvalues of A5
eigs_sym(A5, k, which = "SM")

## another way to do this: use the sigma argument
eigs_sym(A5, k, sigma = 0)

## The results should be the same,
## but the latter method is far more stable on large matrices

```

---

svds

*Find the Largest  $k$  Singular Values/Vectors of a Matrix*


---

## Description

This function is a simple wrapper of the `svds()` function in the **RSpectra** package. Also see the documentation there.

Given an  $m$  by  $n$  matrix  $A$ , function `svds()` can find its largest  $k$  singular values and the corresponding singular vectors. It is also called the Truncated Singular Value Decomposition since it only contains a subset of the whole singular triplets.

Currently `svds()` supports matrices of the following classes:

<code>matrix</code>	The most commonly used matrix type, defined in <b>base</b> package.
<code>dgeMatrix</code>	General matrix, equivalent to <code>matrix</code> , defined in <b>Matrix</b> package.
<code>dgCMatrix</code>	Column oriented sparse matrix, defined in <b>Matrix</b> package.
<code>dgRMatrix</code>	Row oriented sparse matrix, defined in <b>Matrix</b> package.
<code>dsyMatrix</code>	Symmetrix matrix, defined in <b>Matrix</b> package.

Note that when  $A$  is symmetric, SVD reduces to eigen decomposition, so you may consider using `eigs()` instead.

## Usage

```
svds(A, k, nu = k, nv = k, opts = list(), ...)
```

**Arguments**

A	The matrix whose truncated SVD is to be computed.
k	Number of singular values requested.
nu	Number of left singular vectors to be computed. This must be between 0 and k.
nv	Number of right singular vectors to be computed. This must be between 0 and k.
opts	Control parameters related to the computing algorithm. See <b>Details</b> below.
...	Currently not used.

**Details**

The `opts` argument is a list that can supply any of the following parameters:

`ncv` Number of Lanczos basis vectors to use. More vectors will result in faster convergence, but with greater memory use. `ncv` must satisfy  $k < ncv \leq p$  where  $p = \min(m, n)$ . Default is  $\min(p, \max(2*k+1, 20))$ .

`tol` Precision parameter. Default is 1e-10.

`maxitr` Maximum number of iterations. Default is 1000.

**Value**

A list with the following components:

d	A vector of the computed singular values.
u	An $m$ by $nu$ matrix whose columns contain the left singular vectors. If $nu == 0$ , NULL will be returned.
v	An $n$ by $nv$ matrix whose columns contain the right singular vectors. If $nv == 0$ , NULL will be returned.
nconv	Number of converged singular values.
niter	Number of iterations used.
nops	Number of matrix-vector multiplications used.

**Author(s)**

Yixuan Qiu <<http://statr.me>>

**See Also**

[eigen\(\)](#), [svd\(\)](#), [eigs\(\)](#).

**Examples**

```
m = 100
n = 20
k = 5
set.seed(111)
A = matrix(rnorm(m * n), m)

svds(A, k)
svds(t(A), k, nu = 0, nv = 3)

## Sparse matrices
library(Matrix)
A[sample(m * n, m * n / 2)] = 0
Asp1 = as(A, "dgCMatrix")
Asp2 = as(A, "dgRMatrix")

svds(Asp1, k)
svds(Asp2, k, nu = 0, nv = 0)
```

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