

# Package ‘SpectraStash’

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**Title** Serialize and restore Spectra objects in interoperable file formats

**Version** 0.99.2

**Description** The serialization mechanism of R allows to save and load R data objects in a binary format, that can however not be read by other programming languages or software. The SpectraStash package implements the serialization methods from the MsStash package for Spectra objects and its MsBackend classes. A variety of different file formats and types, including HDF5 and JSON-based formats defined by the Bioconductor *\*alabaster\** package are supported. The file type can be defined and configured through a second argument ``param`` of the save/read methods.

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MsBackendCachedStash    *Stash for MsBackendCached*

---

## Description

The `Spectra::MsBackendCached` backend keeps a cache of spectra metadata (spectra variables) in an internal `data.frame` adding thus support for (temporarily) changing or adding spectra variables for purely read-only `MsBackend` classes. This backend is used e.g. by the `MsBackendSql::MsBackendSql` backend allowing to add or replace spectra variables without affecting the content of the underlying data base used by the `MsBackendSql`.

The stash of a `MsBackendCached` contains therefore the local spectra data cache (if present), the names of the available spectra variables and the total number of spectra. Supported stash formats are listed in the sections below.

## Usage

```
## S4 method for signature 'MsBackendCached,PlainTextParam'
saveMsObject(object, param, ...)

## S4 method for signature 'MsBackendCached,PlainTextParam'
readMsObject(object, param, ...)

## S4 method for signature 'MsBackendCached'
saveObject(x, path, ...)

## S4 method for signature 'MsBackendCached,AlabasterParam'
saveMsObject(object, param, ...)

## S4 method for signature 'MsBackendCached,AlabasterParam'
readMsObject(object, param, ...)
```

**Arguments**

|        |                                                                                      |
|--------|--------------------------------------------------------------------------------------|
| object | An MsBackendCached object.                                                           |
| param  | Either a PlainTextParam or AlabasterParam.                                           |
| ...    | Currently ignored.                                                                   |
| x      | An MsBackendCached object.                                                           |
| path   | For saveObject(): character(1) with the path where the object should be stored into. |

**Details**

Notes for stash-functionality for MsBackend objects extending MsBackendCached:

- saveMsObject() and saveObject() will fail if the stash directory already exist. Thus, stash functions of backend implementations extending MsBackendCached should **first** call the MsBackendCached's saveMsObject() or saveObject() **before** exporting their respective content to the stash directory.

**Value**

readMsObject() returns a [Spectra::MsBackendCached](#) object.

**alabaster-based format, AlabasterParam**

The content from all slots of the MsBackendCached are stored using functionality from the *alabaster.base* package into separate sub-folders of the base stash directory. These are:

- *local\_data*: for the data.frame with the locally cached spectra variables (slot @localData).
- *nspectra*: (integer(1)) with the number of spectra.
- *spectra\_variables*: (character) with the names of the object's spectra variables.

**Text-file format, PlainTextParam**

The data files written into the stash are:

- *ms\_backend\_data.txt*: tabulator separated text file with the content of the @localData slot.
- *ms\_backend\_nspectra.txt*: the number of spectra.
- *ms\_backend\_spectra\_variables.txt*: the names of the object's spectra variables (tabulator separated).

**Author(s)**

Johannes Rainer

**Examples**

```
library(Spectra)

## Create an empty `MsBackendCached` object
be <- MsBackendCached()

## Stash the object in alabaster-format in a temporary directory
ap <- AlabasterParam(file.path(tempdir(), "cache-stash"))
```

```

saveMsObject(be, ap)

## The content of the stash folder:
dir(file.path(tempdir(), "cache-stash"))

## Restore the object
res <- readMsObject(MsBackendCached(), ap)
res

```

---

MsBackendHdf5PeaksStash

*MsBackendHdf5Peaks Stash*

---

## Description

MsBackendHdf5Peaks classes can be stashed to (or read from) plain text file-based or *alabaster*-based formats using the `saveMsObject()` and `readMsObject()` functions combined with the [PlainTextParam](#) and [AlabasterParam](#) parameter objects, respectively. In both cases, data files are stored into the specified directory. By default, only the backend's spectra metadata is stored in that folder. Setting parameter `consolidate = TRUE` will also copy the HDF5-format peaks data files (containing the  $m/z$  and intensity values) of the backend into the folder generating a self-consistent stash. The paths to the data storage files are also updated to relative paths enabling to directly restore the object from the stash when the stash folder was copied to another computer or location on the file system (i.e., without the use of parameter `spectraPath`).

Details on the stored files are provided in the sections below.

## Usage

```

## S4 method for signature 'MsBackendHdf5Peaks,PlainTextParam'
saveMsObject(object, param, consolidate = FALSE)

## S4 method for signature 'MsBackendHdf5Peaks,PlainTextParam'
readMsObject(object, param, spectraPath = character())

## S4 method for signature 'MsBackendHdf5Peaks'
saveObject(x, path, consolidate = FALSE, ...)

## S4 method for signature 'MsBackendHdf5Peaks,AlabasterParam'
saveMsObject(object, param, consolidate = FALSE)

## S4 method for signature 'MsBackendHdf5Peaks,AlabasterParam'
readMsObject(object, param, spectraPath = character())

```

## Arguments

|                          |                                                                                                                                                                                      |
|--------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>object</code>      | An MsBackendHdf5Peaks object.                                                                                                                                                        |
| <code>param</code>       | Either a PlainTextParam or AlabasterParam.                                                                                                                                           |
| <code>consolidate</code> | logical(1) whether in addition to the spectra metadata also the peaks data file (in HDF5 format) should be stored in the stash folder. Default is <code>consolidate = FALSE</code> . |

|             |                                                                                                                                                                                                              |
|-------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| spectraPath | For readMsObject(): optional character(1) with the path to the peaks data in HDF5-format (in case they are no longer available in the folder referred to by the original stashed MsBackendHdf5Peaks object). |
| x           | An MsBackendHdf5Peaks object.                                                                                                                                                                                |
| path        | For saveObject(): character(1) with the path where the object should be stored in.                                                                                                                           |
| ...         | Currently ignored.                                                                                                                                                                                           |

## Details

A MsBackendHdf5Peaks stash will by default only contain the spectra metadata (spectra variables) but no  $m/z$  and intensity values. The reference to the original HDF5-format peaks data files are stored as spectra variable *dataStorage*. If these files were moved or if the stash was copied to a different computer, the path to these original data files needs to be provided to the readMsObject() function with parameter spectraPath. Alternatively, with consolidate = TRUE, it is also possible to **copy** the peaks data files to the stash directory generating a self-contained data stash. Note however that in this case two copies of all data files exist (in the original location **and** the stash directory).

## Value

readMsObject() returns an `Spectra::MsBackendHdf5Peaks` object.

## *alabaster*-based format, AlabasterParam

With AlabasterParam, the spectra metadata will be exported (or imported) through the *alabaster* framework. Similar to the PlainTextParam, consolidate = TRUE will also copy the HDF5-format peaks data files to the stash directory.

## Text-file format, PlainTextParam

The saveMsObject() function with the PlainTextParam stores the spectra metadata (spectra variables) of an MsBackendHdf5Peaks to a plain tabulator delimited text file with the name *ms\_backend\_spectra\_data.txt* in the directory specified with parameter path of the PlainTextParam object. Depending on parameter consolidate also the peaks data files (in HDF5 format) will be copied to the stash folder (with consolidate = TRUE).

## Author(s)

Johannes Rainer

## Examples

```
library(Spectra)
library(SpectraStash)
## Create an example MsBackendHdf5Peaks backend from a single mzML file
library(MsDataHub)
tmp <- backendInitialize(MsBackendMzR(), X20171016_POOL_POS_1_105.134.mzML())
be_h5 <- backendInitialize(MsBackendHdf5Peaks(), data = spectraData(tmp),
  hdf5path = file.path(tempdir(), "h5_backend"))
be_h5

d <- file.path(tempdir(), "example_hdf5")
ptp <- PlainTextParam(path = d)
```

```

## Store the object into the stash, including the peaks data files.
saveMsObject(be_h5, ptp, consolidate = TRUE)

## List the content of the folder: ms_backend_spectra_data.txt file
## with the spectra metadata and an HDF5 file with the peaks data:
dir(d)

## Restore the stashed object
res <- readMsObject(MsBackendHdf5Peaks(), ptp)

## Store the object in an alabaster-format stash
d <- file.path(tempdir(), "example_hdf5_2")

ap <- AlabasterParam(d)
saveMsObject(be_h5, ap)

## Check the content of the stash; with the default (`consolidate = FALSE`)
## no HDF5 data file was moved.
dir(d)

## Restore the object again
res <- readMsObject(MsBackendHdf5Peaks(), ap)
res

```

---

MsBackendMemoryStash    *Stash for MsBackendMemory and MsBackendDataFrame*

---

## Description

The stash for the in-memory MS backends [Spectra::MsBackendMemory](#) and [Spectra::MsBackendDataFrame](#) contains both the spectra variables (spectra metadata) as well as the peaks data ( $m/z$  and intensity values). Backend objects can be stashed and restored with the `saveMsObject()` and `readMsObject()`, respectively. In addition, the `saveObject()` and `readObject()` functions from *alabaster.base* are supported.

## Usage

```

## S4 method for signature 'MsBackendInMemory,PlainTextParam'
saveMsObject(object, param, ...)

## S4 method for signature 'MsBackendInMemory,PlainTextParam'
readMsObject(object, param, ...)

## S4 method for signature 'MsBackendInMemory'
saveObject(x, path, ...)

## S4 method for signature 'MsBackendInMemory,AlabasterParam'
saveMsObject(object, param, ...)

## S4 method for signature 'MsBackendInMemory,AlabasterParam'
readMsObject(object, param, ...)

```

**Arguments**

|        |                                                                                      |
|--------|--------------------------------------------------------------------------------------|
| object | An MsBackendMemory or MsBackendDataFrame object.                                     |
| param  | Either a PlainTextParam or AlabasterParam.                                           |
| ...    | Currently ignored.                                                                   |
| x      | An MsBackendMemory or MsBackendDataFrame object.                                     |
| path   | For saveObject(): character(1) with the path where the object should be stored into. |

**Details**

To support storing spectra **and** peaks variables, the MsBackendMemory is converted to a [Spectra::MsBackendHdf5Peaks](#) object with the full peaks data stored into a *peaks.h5* HDF5 file within the stash directory. Due to the nested directory structure it is possible to load a MsBackendMemory stash either as a MsBackendMemory or a MsBackendHdf5Peaks.

**Value**

readMsObject() returns a restored backend.

***alabaster-based format*, AlabasterParam**

The full data is stored as an *alabaster*-format [MsBackendHdf5PeaksStash](#) in a directory *backend* within the stash folder. Due to this nesting it is possible to load the data either as MsBackendMemory or MsBackendHdf5Peaks.

***Text-file format*, PlainTextParam**

The MsBackendMemory stash contains a text-file format [MsBackendHdf5PeaksStash](#) within a sub-folder *backend*. When loading, the data is first imported as a MsBackendHdf5Peaks which is then converted to the resulting MsBackendMemory (with all data materialized into memory).

**Note**

Currently only peaks variables "mz" and "intensity" are supported.

**Author(s)**

Johannes Rainer

**Examples**

```
library(Spectra)

## Create an example `MsBackendMemory` object.
d <- data.frame(msLevel = c(1L, 2L, 1L, 1L),
               rtime = c(12.1, 12.2, 13.1, 13.4))
d$mz <- list(
  c(14.4, 155.2, 186.4),
  c(144.3, 231.3, 345.3, 453.1),
  c(111.2, 142.4, 143.1),
  c(143.3, 144.3, 153.3, 532.3, 641.5)
)
d$intensity <- list(
```

```

      c(323.2, 53.2, 35.5),
      c(43.3, 54.1, 33.1, 53.1),
      c(435.3, 35312.3, 5432.5),
      c(433.5, 55434.2, 43.4, 54362.1, 24435.3)
    )
    be <- backendInitialize(MsBackendMemory(), data = d)
    be

    ## Stash the object in alabaster-format to a temporary folder
    p <- AlabasterParam(file.path(tempdir(), "mem_stash"))
    saveMsObject(be, p)

    ## Show directory content of the stash
    dir(file.path(tempdir(), "mem_stash"))

    ## Restore the object from the stash
    res <- readMsObject(MsBackendMemory(), p)
    res

    ## The in-memory backends store their full MS data through an
    ## [Spectra::MsBackendHdf5Peaks] backend: their peaks data is stored as a
    ## (single) HDF5 file within the stash. A `MsBackendMemory` stash contains
    ## therefore a complete stash of a `MsBackendHdf5Peaks`, which allows to
    ## read the data also as a `MsBackendHdf5Peaks` backend:
    res <- readMsObject(MsBackendHdf5Peaks(),
      AlabasterParam(file.path(tempdir(), "mem_stash", "backend")))
    res

    ## In addition to the `saveMsObject()` and `readMsObject()` functions, also
    ## the `saveObject()` and `readObject()` functions from *alabaster.base* are
    ## supported (for stashes in alabaster format).
    library(alabaster.base)
    res <- readObject(file.path(tempdir(), "mem_stash"))
    res

    ## Storing and restoring a `MsBackendDataFrame` backend or using a stash in
    ## plain text file-based format works analogously.

```

---

MsBackendMzRStash

*MsBackendMzR Stash*


---

## Description

MsBackendMzR classes can be stashed to (or read from) plain text file-based or *alabaster*-based formats using the [saveMsObject\(\)](#) and [readMsObject\(\)](#) functions combined with the [PlainTextParam](#) and [AlabasterParam](#) parameter objects, respectively. Setting parameter `consolidate = TRUE` in the `saveMsObject()` or `saveObject()` function will copy also the original MS data files into the folder generating a self-consistent stash. This stash folder can also be copied to another computer or location in the file system without the need to use parameter `spectraPath` when restoring the data.

Additional properties of the stash formats are described in detail in the sections below.

## Usage

```
## S4 method for signature 'MsBackendMzR,PlainTextParam'
```

```

saveMsObject(object, param, consolidate = FALSE)

## S4 method for signature 'MsBackendMzR,PlainTextParam'
readMsObject(object, param, spectraPath = character())

## S4 method for signature 'MsBackendMzR'
saveObject(x, path, consolidate = FALSE, ...)

## S4 method for signature 'MsBackendMzR,AlabasterParam'
saveMsObject(object, param, consolidate = FALSE)

## S4 method for signature 'MsBackendMzR,AlabasterParam'
readMsObject(object, param, spectraPath = character())

```

## Arguments

|             |                                                                                                                                                                                                               |
|-------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| object      | An MsBackendMzR object.                                                                                                                                                                                       |
| param       | Either a PlainTextParam or AlabasterParam.                                                                                                                                                                    |
| consolidate | logical(1) whether in addition to the spectra metadata also the original MS data files should be stored in the stash folder. Default is consolidate = FALSE.                                                  |
| spectraPath | For readMsObject(): optional character(1) with the path to the MS data files (mzML, mzXML or CDF) in case they are no longer available in the folder referred to by the original stashed MsBackendMzR object. |
| x           | An MsBackendMzR object.                                                                                                                                                                                       |
| path        | For saveObject(): character(1) with the path where the object should be stored in.                                                                                                                            |
| ...         | Currently ignored.                                                                                                                                                                                            |

## Details

MsBackendMzR objects don't contain any peaks data (i.e.,  $m/z$  and intensity values) but retrieve these from the original MS data files (in mzML, mzXML or CDF format). Unless consolidate = TRUE is used, a MsBackendMzR stash will therefore only contain the spectra metadata (i.e., the spectra variables) but no peaks data. The reference to the original MS data files is stored as spectra variable *dataStorage* and if the files are no longer available in the directory specified by *dataStorage* the restored object will not be valid, unless the new location is provided with parameter spectraPath.

## Value

readMsObject() returns an [Spectra::MsBackendMzR](#) object.

## *alabaster*-based format, AlabasterParam

The saveMsObject() with an AlabasterParam parameter object stashes the provided MsBackendMzR object in an *alabster*-based format into the directory defined with argument param of the AlabasterParam. readMsObject() with AlabasterParam restores a previously stashed MsBackend object. Optional parameter spectraPath allows to specify the storage path of the MS data files referenced by the MsBackendMzR (in case they are no longer in the same directory when saving the object).

In addition, the *alabaster* methods saveObject() and readObject() can be used to save and read MsBackendMzR objects.

**Text-file format, PlainTextParam**

The `saveMsObject()` function with the `PlainTextParam` stores the spectra metadata (spectra variables) of an `MsBackendMzR` to a plain tabulator delimited text file with the name *ms\_backend\_spectra\_data.txt* in the directory specified with parameter `path` of the `PlainTextParam` object. Importantly, the peaks data (the *m/z* and intensity values) are **not** exported with `saveMsObject()`.

`readMsObject()` restores a previously stashed `MsBackendMzR` object from the directory specified with parameter `path` of the `PlainTextParam`.

The additional parameter `spectraPath` of `readMsObject()` allows to define the path to the MS data files containing the full MS data (i.e., the *mzML*, *mzXML* or *CDF* files referred to by the `MsBackendMzR`).

**Author(s)**

Philippine Louail, Johannes Rainer

**Examples**

```
library(SpectraStash)
library(Spectra)
library(MsDataHub)

## Create a MsBackendMzR from test data
be <- backendInitialize(MsBackendMzR(), PestMix1_DDA.mzML())
be

## Define a folder where to stash the object
pth <- file.path(tempdir(), "mzr_stash")

## Stash the object to this folder in a plain text-based format
saveMsObject(be, PlainTextParam(pth))

## Restore the stashed object
res <- readMsObject(MsBackendMzR(), PlainTextParam(pth))
res

## Clean-up
unlink(pth, recursive = TRUE)

## Store the data in *alabaster* format including also the original MS
## data files (`consolidate = TRUE`)
saveMsObject(be, AlabasterParam(pth), consolidate = TRUE)

## Get the directory content of the stash folder:
dir(pth)

## Restore the object
res <- readMsObject(MsBackendMzR(), AlabasterParam(pth))
res

## If the data is exported with `consolidate = FALSE` (the default), the
## new location of MS data files could be provided with parameter
## `spectraPath` of the `readMsObject()` function in case they are no
## longer in the path referenced by the stashed object.

## Clean-up
```

```
unlink(pth, recursive = TRUE)
```

SpectraStash

*Spectra Stash*

## Description

Spectra objects can be stashed to (or read from) plain text file-based or *alabaster*-based formats using the `saveMsObject()` or `readMsObject()` functions configured with the [PlainTextParam](#) or [AlabasterParam](#) parameter objects, respectively. In both cases, the data from the Spectra object is stored into the *stash* directory defined with the parameter object. Depending on the used MS backend (and parameters used), the stash can also contain the MS data files.

At present, Spectra objects using one of the following MS data backends are supported:

- MsBackendMzR: see [MsBackendMzRStash](#) for details and options.
- MsBackendHdf5Peaks: see [MsBackendHdf5PeaksStash](#) for details and options.

The data backend of any Spectra backend can eventually be changed to one of the above backends using the `Spectra::setBackend()` method to support saving the object into a Spectra stash. Support for additional backends respectively data representations might also be provided by separate R packages.

Details on the stash formats are provided in the respective sections below.

## Usage

```
## S4 method for signature 'Spectra,PlainTextParam'
saveMsObject(object, param, ...)
```

```
## S4 method for signature 'Spectra,PlainTextParam'
readMsObject(object, param, ...)
```

```
## S4 method for signature 'Spectra'
saveObject(x, path, ...)
```

```
## S4 method for signature 'Spectra,AlabasterParam'
saveMsObject(object, param, ...)
```

```
## S4 method for signature 'Spectra,AlabasterParam'
readMsObject(object, param, ...)
```

## Arguments

|                     |                                                                                                                                                                                                                                                                                                                                                               |
|---------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>object</code> | A Spectra object.                                                                                                                                                                                                                                                                                                                                             |
| <code>param</code>  | Either a <code>PlainTextParam</code> or <code>AlabasterParam</code> .                                                                                                                                                                                                                                                                                         |
| <code>...</code>    | additional arguments passed to the <code>saveMsObject</code> or <code>readMsObject</code> method of the Spectra's MsBackend, such as for example <code>consolidate</code> or <code>spectraPath</code> . See the <code>saveMsObject()</code> and <code>readMsObject()</code> documentation of the used MsBackend class for information on supported arguments. |
| <code>x</code>      | A Spectra object.                                                                                                                                                                                                                                                                                                                                             |
| <code>path</code>   | For <code>saveObject()</code> : character(1) with the path where the object should be stored in.                                                                                                                                                                                                                                                              |

**Value**

`readMsObject()` returns a [Spectra::Spectra](#) object.

***alabaster-based format*, AlabasterParam**

With `AlabasterParam`, the `Spectra` object will be exported (or imported) through the *alabaster* framework as a set of JSON and/or HDF5 files. The content of each slot is stored to a separate file with the name matching the slot name (converted to *snake\_case*). The object's `MsBackend` is stored into a sub-folder *backend* within the stash folder.

For information on the MS backend's data stash see the respective documentation.

**Text-file format, PlainTextParam**

For this format, the data content of a `Spectra` object is stored into the files:

- *spectra\_slots.txt*: plain text file containing the *processing queue* variables (separated by a "|"), the processing log messages (separated by a "|"), the processing chunk size and the `MsBackend` class used.
- *spectra\_processing\_queue.json*: the object's processing queue serialized in JSON format. It can be unserialized using `jsonlite::unserializeJSON()`.

For information on the MS backend's data see the respective documentation.

**Author(s)**

Johannes Rainer, Philippine Louail

**Examples**

```
## Create a Spectra object from two example MS data files (from MsDataHub)
library(Spectra)
library(MsDataHub)
s <- Spectra(
  c(X20171016_POOL_POS_1_105.134.mzML(),
    X20171016_POOL_POS_3_105.134.mzML()))
s

## Filter the intensities of the Spectra removing peaks with an intensity
## below 100
s <- filterIntensity(s, intensity = 100)

## Define the format and location of the `Spectra` stash: use the
## *alabaster*-based format and store the stash in a folder named
## *spectra_stash* in a temporary directory
d <- file.path(tempdir(), "spectra_stash")
ap <- AlabasterParam(d)

## Stash the `Spectra` object copying in addition the MS data files into the
## stash (`consolidate = TRUE`).
saveMsObject(s, ap, consolidate = TRUE)

## Show the content of the stash
dir(d)

## Read the `Spectra` object from the stash:
```

```
res <- readMsObject(Spectra(), ap)
res

## It is also possible to read individual contents from the stash. The
## directory *backend* contains for example the stashed `MsBackend` of the
## `Spectra` object. To read only the `MsBackend`:
ap2 <- AlabasterParam(file.path(d, "backend"))
b <- readMsObject(MsBackendMzR(), ap2)
b

## Alternatively, that data can also be read directly with the `readObject()`
## method from the *alabaster.base* package:
library(alabaster.base)
b <- readObject(file.path(d, "backend"))
b
```

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