Module Interface Specification for Lattice Boltzmann Solvers

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1 Revision History

Date	Version	Notes
Nov. 25, 2019	1.0	Initial Document

2 Symbols, Abbreviations and Acronyms

See CA Documentation for Lattice Boltzmann Solvers (Michalski, a).

Contents

3 Introduction

The following document details the Module Interface Specifications for Lattice Boltzmann Solvers, which provides a library of services based on Lattice Boltzmann Methods (LBM). LBM are a family of fluid dynamics algorithms for simulating single-phase and multiphase fluid flows, often incorporating additional physical complexities (Chen and Doolen, 1998).

Complementary documents include the System Requirement Specifications and Module Guide. The full documentation and implementation can be found here (Michalski, b).

4 Notation

The structure of the MIS for modules comes from Hoffman and Strooper (1999), with the addition that template modules have been adapted from Ghezzi et al. (2003). The mathematical notation comes from Chapter 3 of Hoffman and Strooper (1999). For instance, the symbol := is used for a multiple assignment statement and conditional rules follow the form $(c_1 \Rightarrow r_1|c_2 \Rightarrow r_2|...|c_n \Rightarrow r_n)$.

The following table summarizes the primitive data types used by Lattice Boltzmann Solvers.

Data Type	**Notation**	**Description**
Boolean	Boolean	true or false
natural number	$\mathbb{N}$	a number without a fractional component in [1, ∞)
real	$\mathbb{R}$	any number in (-∞, ∞)
string	string	single or multiple symbols or digits

The specification of Lattice Boltzmann Solvers uses some derived data types: sequences, strings, and tuples. Sequences are lists filled with elements of the same data type. Strings are sequences of characters. Tuples contain a list of values, potentially of different types. In addition, Lattice Boltzmann Solvers uses functions, which are defined by the data types of their inputs and outputs. Local functions are described by giving their type signature followed by their specification.

5 Module Decomposition

The following table is taken directly from the Module Guide document for this project.

Level 1	**Level 2**
Hardware-Hiding Module	
Behaviour-Hiding Module	M2: System Control Module M3: Input Reading Module M4: Input Checking Module M5: LBM Control Module M6: Streaming Module M7: Collision Module M8: Problem Module M9: Lattice Module M10: Boundary Module
Software Decision Module	M11: Image Rendering Module M12: Data Structure Module M13: Input Types Module

Table 1: Module Hierarchy

6 MIS of M2: System Control Module

The secret of this module is the algorithm to control Lattice Boltzmann Solvers.

6.1 Module

SystemControl

6.2 Uses

- Hardware Hiding
- Input Reading (Section 7)
- LBM Control (Section 9)
- Problem Parameter (Section 12)
- Image Rendering (Section 15)
- Data Structure (Section 16)

6.3 Syntax

6.3.1 Exported Constants

N/A

6.3.2 Exported Access Programs

N/A

6.4 Semantics

6.4.1 State Variables

inputData: DataStructure
problemData: $\mathbb{R}$ & $\mathbb{N}$ [What does this notation mean? This does not look like proper mathematics. —SS]
imageData: array[$\mathbb{R}$]
imageOut: PNG

6.4.2 Environment Variables

N/A

6.4.3 Assumptions

The user has run the Lattice Boltzmann Solvers program. [I don't understand this assumption. —SS]

6.4.4 Access Routine Semantics

N/A

6.4.5 Local Functions

Name	In	Out	Exceptions
mainFunction	-	-	-

6.4.6 Local Function Semantics

mainFunction():

- transition: *out* := N/A
- exception: N/A

The function calls other modules of Lattice Boltzmann Solvers to solve the given problem. The function calls InputReading.inputArray(), followed by ProblemParameter.formatInput() and LBMControl.performLBM(). Finally the module calls ImageRendering.imageFunc() and sends the output of that function to the hardware. [This is vague. Can you write this as pseudo code? —SS]

7 MIS of M3: Input Reading Module

The secret of this module is the algorithm that gathers the input data.

7.1 Module

InputReading

7.2 Uses

- Hardware Hiding
- Input Checking (Section 8)
- Data Structure (Section 16)

7.3 Syntax

7.3.1 Exported Constants

N/A

7.3.2 Exported Access Programs

Name	In	Out	Exceptions
inputArray	-	inputData: DataStructure	NotFound, ErrorRead

7.4 Semantics

7.4.1 State Variables

N/A

7.4.2 Environment Variables

InputLocation (string): "./Input/input.txt" [The environment variable is the file, not the files name. Have a look at the example at https://gitlab.cas.mcmaster.ca/smiths/se2aa4_cs2me3/blob/master/Assignments/PreviousYears/2018/A2/A2.pdf —SS]

7.4.3 Assumptions

The System Control Module M2 (Section 6) has called InputReading.inputArray().

7.4.4 Access Routine Semantics

inputArray():

- transition: *out* := +(inputData[key][value] $\Leftarrow$ ./Input/input.txt) [I have no idea what this notation means. A transition field does not have an output. The left pointing arrow is not a notation that Hoffman and Strooper use. —SS]
- exception: input.txt $\notin$ ./Input/ $\Rightarrow$ NotFound
- exception: (inputData $\Leftarrow$?) $\Rightarrow$ ErrorRead [You should use a conditional rule to combine all of your exceptions in one rule. Two exception fields is confusing, and not part of the template. —SS]

The function will read all lines from the input file and place each value into inputData.

7.4.5 Local Functions

N/A

8 MIS of M4: Input Checking Module

This secret of this module is the algorithm that checks if input values fall within allowable parameters.

8.1 Module

InputChecking

8.2 Uses

- Data Structure (Section 16)

8.3 Syntax

8.3.1 Exported Constants

N/A

8.3.2 Exported Access Programs

Name	In	Out	Exceptions
verifyInputs	inputData: DataStructure	Boolean	OutBounds, UnknwnParm

[The DataStructure module documents an abstract object, but here you are using DataStructure as a type. If it is an ADT, it should be documented differently. If it is an abstract object, you cannot pass it as a parameter; you simply use it in that case. —SS]

8.4 Semantics

8.4.1 State Variables

The set of acceptableRanges is:
LIBRARY: set of $\mathbb{N}$: {1} - Libraries are associated by numbers in the program. The numbers are available for reference in the User Guide. [What does this notation mean? Is the entry after the second full colon the value of the state variable? Is it the initial value of the state variable, or is this a constant? —SS]
PROBLEM: set of $\mathbb{N}$: {1} - Problems are associated by numbers in the program. The numbers are available for reference in the User Guide.
DIMENSIONS: set of $\mathbb{N}$: {2}
VEL_DIRS: set of $\mathbb{N}$: {9}
REYNOLDS_MIN: $\mathbb{R}$: {0.001}
REYNOLDS_MAX: $\mathbb{R}$: {5000}

DENSITY_MIN: $\mathbb{R}$: {0.0708}
DENSITY_MIN: $\mathbb{R}$: {13.6}
BULK_VIS_MIN: $\mathbb{R}$: {0.0001}
BULK_VIS_MIN: $\mathbb{R}$: {20000}
SHEAR_VIS_MIN: $\mathbb{R}$: {0.001}
SHEAR_VIS_MIN: $\mathbb{R}$: {20000}
TIME_MIN: $\mathbb{N}$: {1}

8.4.2 Environment Variables

N/A

8.4.3 Assumptions

The Input Reading Module M3 (Section 7) has called InputChecking.verifyInputs(). [This is confusing. This module assumes that this module has already been called? This sounds like unwanted recursion in the documentation. —SS]

8.4.4 Access Routine Semantics

verifyInputs(inputData):

- output: (inputData[value] ! > acceptableRanges) $\wedge$ (inputData[value] ! < acceptableRanges) $\Rightarrow$ return True
- exception: (inputData[value] > acceptableRanges) $\vee$ (inputData[value] < acceptableRanges) $\Rightarrow$ OutBounds
- exception: inputData[key] $\notin$ inputTypes $\Rightarrow$ UnknwnParm

[Where does value come from? This variable is not bound to anything in this expression. Do you want a quantification over all values? —SS]

The function will iterate through each inputValue InputTypes key and check if the key is known to the program, as well as check if associated values of known keys fall within an acceptable range of the state variables.

8.4.5 Local Functions

N/A

9 MIS of M5: LBM Control Module

The secret of this module is the algorithm which controls the LBM library.

9.1 Module

LBMControl

9.2 Uses

- Streaming (Section 10)
- Collision (Section 11)

9.3 Syntax

9.3.1 Exported Constants

9.3.2 Exported Access Programs

Name	In	Out	Exceptions
performLBM	inputData: DataStructure, problemData: $\mathbb{R}$ & $\mathbb{N}$	imageData: array[$\mathbb{R}$]	-

[You need to decide whether DataStructure is an abstract object, or an abstract data type. —SS] [I think (?) you are using problemData to hold real and natural number data. You need to be more specific about the type of problemData. Is it a tuple with named fields? I know you want to leave things open for different uses. In that case you could define specific options for the problemData type and instantiate the one in this spec that makes sense for the program family member in use. To keep things simple for the final implementation, maybe you can just pick a type of problem and document the fields of the problemData type specifically for that type of problem? —SS]

9.4 Semantics

9.4.1 State Variables

imageData: array[$\mathbb{R}$]

9.4.2 Environment Variables

N/A

9.4.3 Assumptions

The System Control Module M2 (Section 6) has called LBMControl.performLBM(). [This recursive assumption is showing up again. :-) I think this is an assumption you want in the System Control Module, not here? —SS]

9.4.4 Access Routine Semantics

performLBM(inputData, problemData):

- transition: *out* := imageData = $\mathbb{R} \Leftarrow$ Streaming.streamingFunc(), $\mathbb{R} \Leftarrow$ Collision.collisionFunc() [transitions change the state, outputs output values. I don't know which you are trying to do here. The left arrows are also confusing. If you don't know a notation for what you are trying to say, you are better off saying it in words, than inventing a notation. —SS]
- exception: N/A

The function will calculate the vorticity vector values, iterating through each velocity direction, calling the streaming and collision module functions.

9.4.5 Local Functions

N/A

10 MIS of M6: Streaming Module

The secret of this module is the algorithm to calculate the streaming of particles.

10.1 Module

Streaming

10.2 Uses

N/A

10.3 Syntax

10.3.1 Exported Constants

N/A

10.3.2 Exported Access Programs

Name	In	Out	Exceptions
streamingFunc	Velocityi: $\mathbb{R}$, Time: $\mathbb{N}$, PositionVector: $\mathbb{R}$, Force: $\mathbb{R}$, Mass: $\mathbb{R}$	$\mathbb{R}$	NAN

10.4 Semantics

10.4.1 State Variables

N/A

10.4.2 Environment Variables

N/A

10.4.3 Assumptions

The LBM Control Module M5 (Section 9) has called streaming.streamingFunc().

10.4.4 Access Routine Semantics

streamingFunc(Velocityi, Time, PositionVector, Force, Mass):

- transition: $out := f_i(\mathbf{x} + \mathrm{e}_i dt, t + dt) - f_i(\mathbf{x}, t)$
- exception: $(f_i(\mathbf{x} + \mathrm{e}_i dt, t + dt) - f_i(\mathbf{x}, t) >$ maximum size of primitive data type$) \Rightarrow$ NAN

[What is the connection between the parameters of the streaming function and the equation given in the transition? What is the mapping between x, e, Velocityi, etc? You should use the same symbols in the input as you use for the transition. —SS] [The confusion between transition and output has to be addressed throughout the document. —SS] The function calculates the streaming step value for each velocity direction (i).

10.4.5 Local Functions

Name	In	Out	Exceptions
pdfFunc $(f(\mathbf{x}, \mathrm{e}, t))$	Velocityi: $\mathbb{R}$, Time: $\mathbb{N}$, PositionVector: $\mathbb{R}$, Force: $\mathbb{R}$, Mass: $\mathbb{R}$	$\mathbb{R}$	NAN

10.4.6 Local Function Semantics

pdfFunc(Velocityi, Time, PositionVector, Force, Mass):

- transition: $out := f(\mathbf{x}, \mathrm{e}, t) = f(\mathbf{x} + \mathrm{e}dt, \mathrm{e} + \frac{F}{kg}dt, t + dt)$
- exception: $(f(\mathbf{x} + \mathrm{e}dt, \mathrm{e} + \frac{F}{kg}dt, t + dt)) >$ maximum size of primitive data type$) \Rightarrow$ NAN

The function finds the probability that a particle is at position $\mathbf{x}$ and has velocity e at time t.

[Where is the local function used in the specification of Streaming Module? Local functions are only used within the spec of one module. They are not used elsewhere, or part of the required implementation. —SS]

11 MIS of M7: Collision Module

The secret of this module is the algorithm to calculate the collision of particles.

11.1 Module

Collision

11.2 Uses

N/A

11.3 Syntax

11.3.1 Exported Constants

N/A

11.3.2 Exported Access Programs

Name	In	Out	Exceptions
collisionFunc	RelaxationRate : $\mathbb{R}$, Weighti: $\mathbb{R}$, Density: $\mathbb{R}$, UnitVector: $\mathbb{R}$, MacroscopicVelocity: $\mathbb{R}$, SpeedSound: $\mathbb{R}$, VelocityDirection: $\mathbb{N}$	$\mathbb{R}$	NAN

11.4 Semantics

11.4.1 State Variables

N/A

11.4.2 Environment Variables

maxVariableSize = The maximum allowable value held in the variable.
minVariableSize = The minimum allowable value held in the variable.

11.4.3 Assumptions

The LBM Control Module M5 (Section 9) has called Collision.streamingFunc().

11.4.4 Access Routine Semantics

collisionFunc(RelaxationRate, Weighti, Density, UnitVector, MacroscopicVelocity, SpeedSound, VelocityDirection):

- transition: $out := \frac{1}{\tau}(f_i^{eq} - f_i)$
- exception: $(\frac{1}{\tau}(f_i^{eq} - f_i) > \text{maxVariableSize}) \vee (\frac{1}{\tau}(f_i^{eq} - f_i) < \text{minVariableSize}) \Rightarrow \text{NAN}$

[I do not see the mapping between the parameters and the transition equation. I won't continue to write this comment, but it applies throughout this document. —SS]

The function calculates the collision step value for each velocity direction (i).

11.4.5 Local Functions

Name	In	Out	Exceptions
edfFunc (f_i^{eq})	Weighti: $\mathbb{R}$, Density: $\mathbb{R}$, UnitVector: $\mathbb{R}$, MacroscopicVelocity: $\mathbb{R}$, SpeedSound: $\mathbb{R}$, VelocityDirection: $\mathbb{N}$	$\mathbb{R}$	NAN
relFunc (f_i)	Weighti: $\mathbb{R}$, Density: $\mathbb{R}$, UnitVector: $\mathbb{R}$, MacroscopicVelocity: $\mathbb{R}$, SpeedSound: $\mathbb{R}$, VelocityDirection: $\mathbb{N}$	$\mathbb{R}$	NAN

11.4.6 Local Function Semantics

edfFunc(Weighti, Density, UnitVector, MacroscopicVelocity, SpeedSound, VelocityDirection):

- transition: $out := f_i^{eq} = w_i p(1 + 3 \cdot \frac{\mathbf{e_i} \cdot \mathbf{u}}{c_s^2} + \frac{9}{2} \cdot \frac{(\mathbf{e_i} \cdot \mathbf{u})^2}{c_s^4} - \frac{3}{2} \cdot \frac{\mathbf{u} \cdot \mathbf{u}}{c_s^4})$
- exception: $(w_i p(1 + 3 \cdot \frac{\mathbf{e_i} \cdot \mathbf{u}}{c_s^2} + \frac{9}{2} \cdot \frac{(\mathbf{e_i} \cdot \mathbf{u})^2}{c_s^4} - \frac{3}{2} \cdot \frac{\mathbf{u} \cdot \mathbf{u}}{c_s^4}) > \text{maxVariableSize}) \vee (w_i p(1 + 3 \cdot \frac{\mathbf{e_i} \cdot \mathbf{u}}{c_s^2} + \frac{9}{2} \cdot \frac{(\mathbf{e_i} \cdot \mathbf{u})^2}{c_s^4} - \frac{3}{2} \cdot \frac{\mathbf{u} \cdot \mathbf{u}}{c_s^4}) < \text{minVariableSize}) \Rightarrow \text{NAN}$

The function calculates the equilibrium distribution for each velocity direction (i).

relFunc(Weighti, Density, UnitVector, MacroscopicVelocity, SpeedSound, VelocityDirection):

- transition: $out := f_i = f_i - \frac{1}{\tau}(f_i^{eq} - f_i)$
- exception: $(f_i - \frac{1}{\tau}(f_i^{eq} - f_i) > \text{maxVariableSize}) \vee (f_i - \frac{1}{\tau}(f_i^{eq} - f_i) < \text{minVariableSize})$ $\Rightarrow$ NAN

The function calculates the relaxation update for each velocity direction (i).

12 MIS of M8: Problem Module

The secret of this module is the structure of the LBM input parameters.

12.1 Module

ProblemParameter

12.2 Uses

- Lattice (Section 13)
- Boundary (Section 14)
- Data Structure (Section 16)

12.3 Syntax

12.3.1 Exported Constants

N/A

12.3.2 Exported Access Programs

Name	In	Out	Exceptions
formatInput	inputData: DataStructure	problemData: $\mathbb{R}$ & $\mathbb{N}$	-

12.4 Semantics

12.4.1 State Variables

N/A

12.4.2 Environment Variables

N/A

12.4.3 Assumptions

The System Control Module M2 (Section 6) has called ProblemParameter.formatInput().

12.4.4 Access Routine Semantics

formatInput(inputData):

- transition: *out* := problemData = $\mathbb{N} \in$ inputData, $\mathbb{R} \Leftarrow$ Boundary.getBoundary(), $\mathbb{R} \Leftarrow$ Lattice.getWeights()
- exception: N/A

The function will set up the structure for the LBM input parameters based on the library that the user has requested. The function will use the Lattice and Boundary module functions.

12.4.5 Local Functions

N/A

13 MIS of M9: Lattice Module

The secret of this module is the structure of the lattice model.

13.1 Module

Lattice

13.2 Uses

- Data Structure (Section 16)

13.3 Syntax

13.3.1 Exported Constants

parameterValues := (9, 4/9, 1/9, 1/9, 1/9, 1/9, 1/36, 1/36, 1/36, 1/36)

The above holds the coefficient weights for velocity directions of a Q9 model.

13.3.2 Exported Access Programs

Name	In	Out	Exceptions
getWeights	inputData: DataStructure	$\mathbb{R}$	NoLattice

13.4 Semantics

13.4.1 State Variables

N/A

13.4.2 Environment Variables

N/A

13.4.3 Assumptions

The Problem Module M8 (Section 12) has called Lattice.getWeights().

13.4.4 Access Routine Semantics

getWeights(inputData):

- transition: *out* := Weighti ($\mathbb{R}$) $\in$ parameterValues
- exception: inputData[VelocityDirections] $\notin$ parameterValues $\Rightarrow$ NoLattice

The function sets coefficient weight data for the input lattice model, and returns an error if the weight data is not available for the input lattice model.

13.4.5 Local Functions

N/A

14 MIS of M10: Boundary Module

The secret of this module is the structure of the model boundary.

14.1 Module

Boundary

14.2 Uses

- Data Structure (Section 16)

14.3 Syntax

14.3.1 Exported Constants

N/A

14.3.2 Exported Access Programs

Name	In	Out	Exceptions
getBoundary	inputData: DataStructure	$\mathbb{R}$	-

14.4 Semantics

14.4.1 State Variables

N/A

14.4.2 Environment Variables

N/A

14.4.3 Assumptions

The Problem Module M8 (Section 12) has called Boundary.getBoundary().

14.4.4 Access Routine Semantics

getBoundary(inputData):

- transition: *out* := $\mathbb{R} \in$ DataStructure [DataStructure is not a set or a sequence (I don't think?), so this operation does not make sense. Moreover, $\mathbb{R}$ is the set of real numbers. For this to ever return True, DataStructure would have to be a set of sets of

real numbers, with the possibility that one of those sets is all the real numbers. Also, this expression evaluates to True of False, but the type of your output is real. —SS]

- exception: N/A

The function returns the boundary from the DataStructure library.

14.4.5 Local Functions

N/A

15 MIS of M11: Image Rendering Module

The algorithm to convert the LBM output into an image.

15.1 Module

ImageRendering

15.2 Uses

N/A

15.3 Syntax

15.3.1 Exported Constants

N/A

15.3.2 Exported Access Programs

Name	In	Out	Exceptions
imageFunc	imageData: array[$\mathbb{R}$]	imageOut: PNG	IncorrectFormat

15.4 Semantics

15.4.1 State Variables

N/A

15.4.2 Environment Variables

N/A [An environment variable for the png file would make sense here, rather than outputting the PNG file. —SS]

15.4.3 Assumptions

The System Control Module M2 (Section 12) has called ImageRendering.imageFunc() of this module.

15.4.4 Access Routine Semantics

imageFunc(imageData[]):

- transition: *out* := imageOut: PNG
- exception: (imageData[] $\neq \mathbb{R} \Rightarrow$ IncorrectFormat)

The function converts the information from the LBM algorithm output (for example the vorticity vector values) into an image format using an external image library.

15.4.5 Local Functions

N/A

16 MIS of M12: Data Structure Module

The format of a non-primitive data structure for input variables.

16.1 Module

DataStructure

16.2 Uses

- Input Types (Section 17)

16.3 Syntax

16.3.1 Exported Constants

N/A

16.3.2 Exported Access Programs

Name	In	Out	Exceptions
init	-	-	-
add	InputTypes, $\mathbb{R}$	-	IncorrectFormat
getElm	InputTypes	$\mathbb{R}$	DoesNotExist

16.4 Semantics

16.4.1 State Variables

s: set of tuple of (key: InputType, value: $\mathbb{R}$) [You are using a variable as a type here. Our mathematical framework does not handle dependent types. I'm sure there is an abstract mathematics we could use here, but using that would be a big jump when there is so much work to do to get the regular Hoffman and Strooper math correct. I suggest that you document for one LB type of problem and drop the goal of being generic. —SS]

16.4.2 State Invariant

N/A

16.4.3 Assumptions

DataStructure.init() is called before any other access program.

16.4.4 Access Routine Semantics

init():

- transition: $s := \{\}$
- exception: N/A

add(InputTypes, $\mathbb{R}$):

- transition: $s := s \cup \{\langle$ InputTypes, $\mathbb{R}$ $\rangle\}$
- exception: ($\langle$ InputTypes, value $\rangle$ | value is not a $\mathbb{R} \Rightarrow$ IncorrectFormat)

remove(InputTypes):

- transition: $s := s$ - $\{\langle$ InputTypes, $\mathbb{R}$ $\rangle\}$ where $\langle$ InputTypes, $\mathbb{R}$ $\rangle \in s$
- exception: ($\langle$ InputTypes, $\mathbb{R}$ $\rangle \notin s \Rightarrow$ DoesNotExist)

getElm(InputTypes):

- transition: $out := \mathbb{R}$ if $\langle$ InputTypes, $\mathbb{R}$ $\rangle \in s$
- exception: ($\langle$ InputTypes, $\mathbb{R}$ $\rangle \notin s \Rightarrow$ DoesNotExist)

16.4.5 Local Functions

N/A

17 MIS of M13: Input Types Module

The input types for the non-primitive data structures.

17.1 Module

InputTypes

17.2 Uses

N/A

17.3 Syntax

17.3.1 Exported Constants

InputTypes (string) = {Library, Problem, Dimensions, VelocityDirections, ReynoldsNumber, Density, BulkViscosity, ShearViscosity, Time, Density, Viscosity, AccelerationRate, SpeedSound, Velocity, Force, Mass, CrossSectionalArea, MacroscopicVelocity, RelaxationRate} [You might be on to a good idea here, but I can't tell. If there are a finite set of options, you should use an enumerated type, not a string. I'm not sure what you are trying to do. My advice above is to be less generic. I think documenting one specific problem is enough of a challenge. —SS]

17.3.2 Exported Access Programs

N/A

17.4 Semantics

17.4.1 State Variables

N/A

17.4.2 State Invariant

N/A

17.4.3 Assumptions

The Data Structure Module M12 (Section 16) will only use a set of the above InputTypes.

17.4.4 Access Routine Semantics

N/A

17.4.5 Local Functions

N/A

References

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Peter Michalski. Lattice Boltzmann Solvers, b. URL https://github.com/peter-michalski/LatticeBoltzmannSolvers.

18 Appendix

Table 2: Possible Exceptions

Message ID	**Error Message**
DoesNotExist	Error: The input type does not exist.
ErrorRead	Error: Could not read the input file.
IncorrectFormat	Error: The format is not a real number.
NAN	Error: The calculated result is not a number.
NoLattice	Error: The chosen velocity directions do not have a known lattice structure.
NotFound	Error: Input file not found.
OutBounds	Error: The input file parameter X is out of bounds. Please see the User Guide.
UnknwnParm	Error: The parameter X is not known to the system. Please see the User Guide.