

OSCAR: Integrating GAP and Julia

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- 1 Introduction to OSCAR

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All of this is joint work with

- William Hart (TU Kaiserslautern)
- Thomas Breuer (RWTH Aachen)
- Reimer Behrends (TU Kaiserslautern)
- Max Horn (JLU Gießen)
- Markus Pfeiffer (University of St Andrews)
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For a complete list of people involved in the various parts of OSCAR, see <https://oscar.computeralgebra.de/credits>.

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Visionary system surpassing the combined capabilities of the underlying systems

GAP: computational discrete algebra, group and representation theory, general purpose high level interpreted programming language.

julia

Singular: polynomial computations, with emphasis on algebraic geometry, commutative algebra, and singularity theory.

Examples:

Multigraded equivariant Cox rings of toric varieties over number fields

Graphs of groups in division algebras

Matrix groups over polynomial rings with coefficients in number fields

Gröbner fans over fields with discrete valuations

julia

julia

polymake: convex polytopes, polyhedral and stacky fans, simplicial complexes and related objects from combinatorics and geometry.

julia

ANTIC: number theoretic software featuring computations in and with number fields and generic finitely presented rings.

The vision for OSCAR

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- make all functionality from each system available in every other system;
- make all systems share a common mid-level programming layer.

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 - Prototype for accessing most polymake functionality from Julia
- GAP: Second part of talk

Example: Using Singular with Nemo rings

Example for using Nemo number fields as coefficient rings in Singular

```
Julia_rings_with_Singular.ipynb
```

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<https://oscar.computeralgebra.de>

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On the page you can find

- news,
- blog posts,
- examples,
- and installation instructions.

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JuliaInterface and GAP.jl

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<https://github.com/oscar-system>

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- Integers
- Floats
- Strings
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- Nested lists of the above to Arrays or Tuples

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- Julia functions can be used like GAP functions
- If necessary and possible, input data is converted to Julia
- Calling only possible for convertible types and Julia objects

JuliaInterface: Julia functions as kernel modules

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```
function orbit( element, generators, action )
  work_set = [ element ]
  return_set = [ element ]
  generator_length = gap_LengthPlist(generators)
  while length(work_set) != 0
    current_element = pop!(work_set)
    for current_generator_number = 1:generator_length
      current_generator = gap_ListElement(generators,
                                          current_generator_number)
      current_result = gap_CallFunc2Args(action,current_element,
                                         current_generator)

      is_in_set = false
      for i in return_set
        if i == current_result
          is_in_set = true
          break
        end
      end
      if ! is_in_set
        push!( work_set, current_result )
        push!( return_set, current_result )
      end
    end
  end
  return return_set
end
```

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```
gap> orbit_c( 1, S, OnPoints );; time;  
46
```

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GAP.jl: using GAP from Julia

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```
julia> S3 = GAP.SymmetricGroup( LibGAP.to_gap( 3 ) )  
GAP: SymmetricGroup( [ 1 .. 3 ] )
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```
julia> LibGAP.from_gap( size_gap, Int64 )  
6
```

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- Flexible type system: Objects can learn about themselves
- Built-in traits: Known properties of objects decide which variant of an algorithm to use
- Immediate propagation: Second execution layer is used to spread properties between objects
- Categorical programming language as defined in the CAP project

Example: Using Singular in GAP via Julia

Example for using Singular in GAP via Julia

```
Using Singular from GAP.ipynb
```

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- This approach can be implemented using build-in techniques in GAP and Julia, but
- it adds a layer of indirections and causes inefficiencies and
- unreachable cycles that involve both GAP and Julia objects cannot be reclaimed, so it leads to memory leaks.

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- This way, all GAP objects are first-class citizens in Julia, and Julia objects are first class citizens in GAP
- Thus using Julia objects from GAP and GAP objects from Julia works without any GC overhead (essentially no penalty at all)

