MODELLING THE COSMOS IN RUBY

The sky is a lie

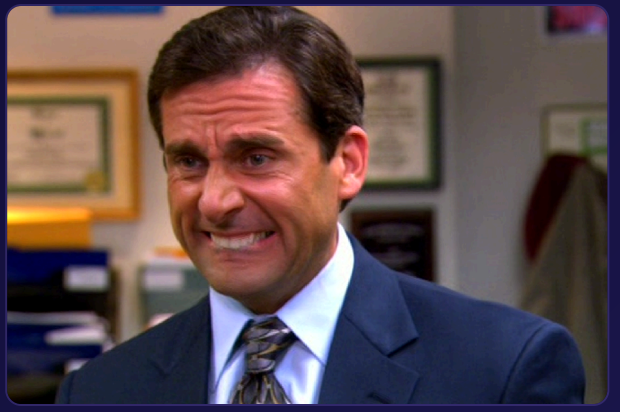
We see what's in the past

Sunrise and sunset times are fake

The Pole Star is not at the celestial pole

A day is not 24 hours

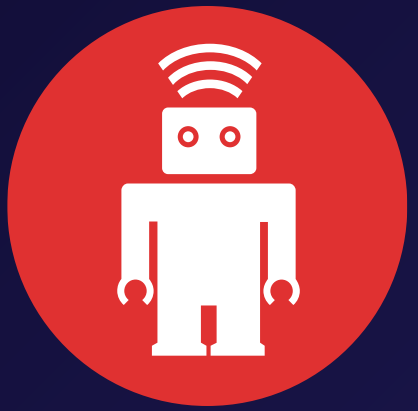
Build an accurate astronomy library with that



Hi, I'm Rémy

@rhannequin

Senior developer at thoughtbot



In love with astronomy

Let's meet and talk

What are we going to talk about?

Complex domain models

Learn code design techniques

Code readability for collaboration and education

Context: Astronoby

Astronomical data and events accessible in Ruby

Position of planets in the sky 🪐

Rising, transit and setting times 🌄

Equinoxes and solstices times ☀️

Moon phases 🌙

Future:

Conjunctions, oppositions

Eclipses

Deep sky objects

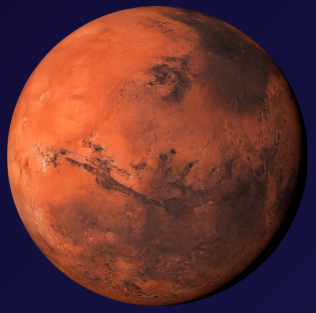
Stargazing planner

Increase scientific support in the Ruby ecosystem

tbot.io/astronoby

Azimuth: 123°44′47″

Altitude: 49°26′14″



Solar System

Barycenter

Vector

Light-time

Precession

Nutation

Aberration

Deflection

Earth shape

Terrestrial time

Barycentric position

Geocentric astrometric position

Geocentric apparent position

Topocentric apparent position

Equatorial coordinates

Horizontal coordinates

How to deal with a large and complex domain?

Domain-Driven Design

DDD? 👍

Introduced in 2003 by Eric Evans

Reflects business domain

Focus on core domain

❌	✅
Technical layers	Business concepts
Large exhaustive models	Multiple models with explicit boundaries
Uniform objects	Entities and value objects

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Ubiquitous Language

Ubiquitous Language

❌

```ruby
class MoonState
  def self.compute(state, time)
    new(
      time: time,
      state: state
    )
  end
end
```

✅

```ruby
class MoonPhase
  def self.full_moon(time)
    new(
      time: time,
      phase: FULL_MOON
    )
  end
end
```

When DDD?

Complex domain

Collaboration

Ruby ❤️ DDD

- ★ OOP
- ★ Expressiveness
- ★ Modules
- ★ Metaprogramming

DDD in Astronoby

Repositories

Ephem

Ephem

```
ephem = Astronoby::Ephem.load("de440s.bsp")

ephem[0, 3].position_at(2460819)
# ⟹ Vector[-71204709, -123739936, -53612310]
```

Domain services

`RiseTransitSetCalculator`

`MoonPhases`

RiseTransitSetCalculator

```ruby
calculator =
  Astronoby::RiseTransitSetCalculator.new(
    body: Astronoby::Sun,
    observer: observer,
    ephem: ephem
  )

event = calculator.event_on(date)
# ⇒ Astronoby::RiseTransitSetEvent object

event.rising_time
# ⇒ 2025-05-23 05:54:08 +0200
```

Value objects

Angle

Instant

Distance

Angle

```ruby
angle = Astronoby::Angle.from_degres(240)

angle.hours
# ⟹ 16.0

angle.cos
# ⟹ -0.5
```

Entities

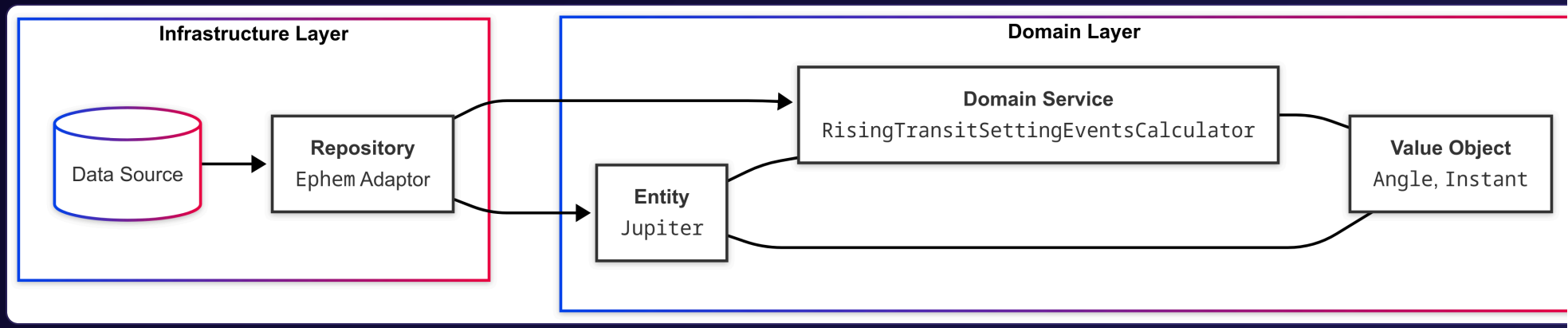
Jupiter

Observer

Jupiter

```ruby
jupiter = Astronoby::Jupiter.new(
  ephem: ephem,
  instant: instant
)

jupiter.apparent.distance.km
# ⟹ 904241448
```


Infrastructure Layer
Data Source
Repository
Ephem Adaptor
Domain Layer
Domain Service
RisingTransitSettingEventsCalculator
Entity
Jupiter
Value Object
Angle, Instant

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ephem = Astronoby::Ephem.load("inpop19a.bsp")

time = Time.utc(2025, 5, 23, 14, 30, 0)
instant = Astronoby::Instant.from_time(time)

geneva = Astronoby::Observer.new(
  latitude: Astronoby::Angle.from_degrees(46.2044),
  longitude: Astronoby::Angle.from_degrees(6.1432),
  elevation: Astronoby::Distance.from_meters(375)
)

mars = Astronoby::Mars.new(instant: instant, ephem: ephem)

topocentric = mars.observed_by(geneva)

topocentric.horizontal.altitude.degrees
# ⟹ 49.4371279134974
```

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```

Value objects

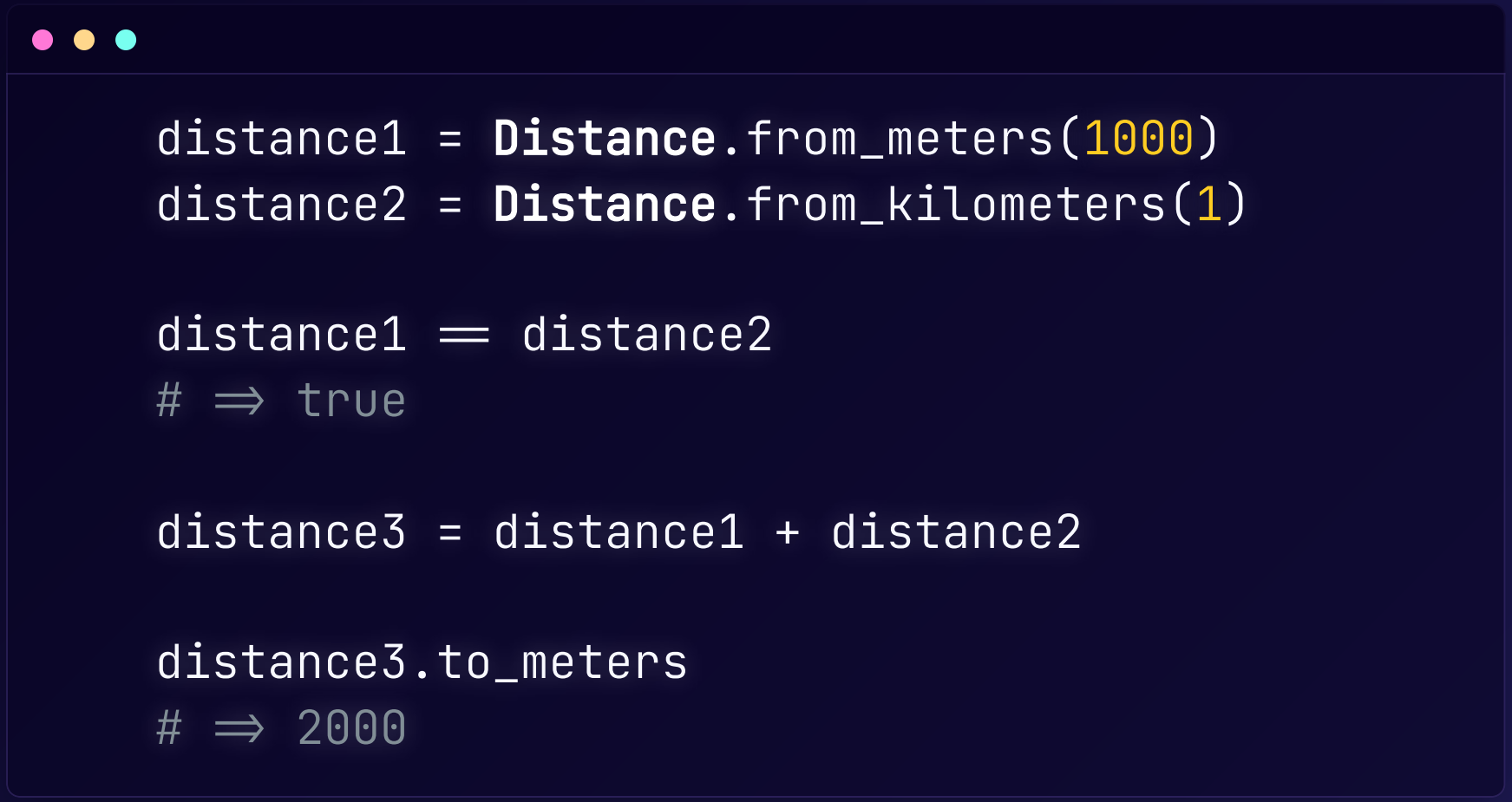
Replace primitives

Encapsulate data

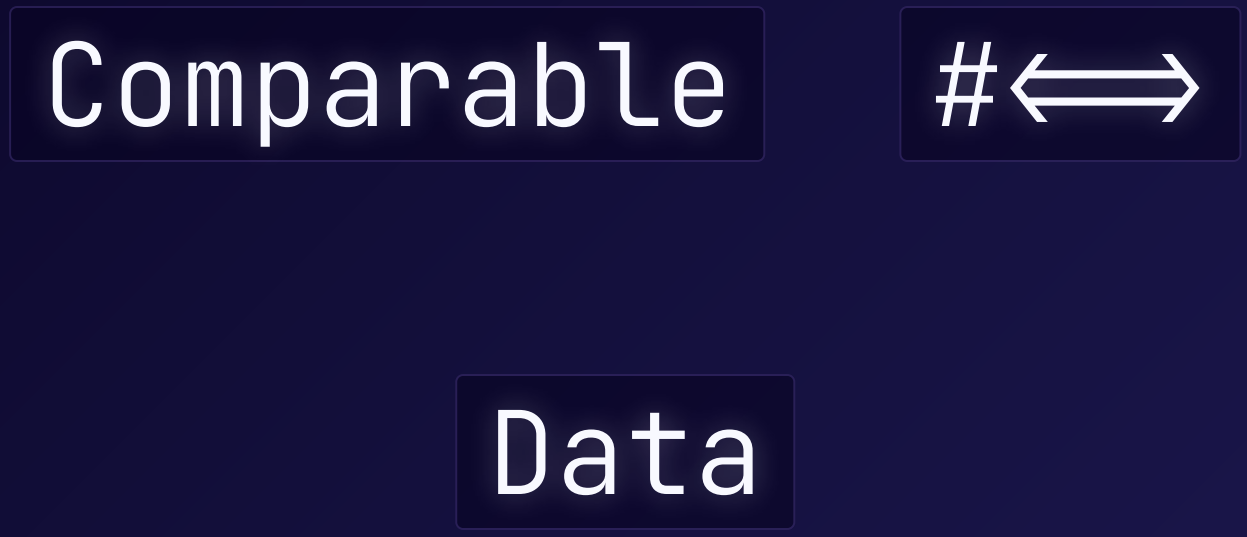
No or little behaviour

Time

```
time = Time.now

time.hour
# ⇒ 16

time.to_i
# ⇒ 1747917900
```



```
distance1 = Distance.from_meters(1000)
distance2 = Distance.from_kilometers(1)

distance1 == distance2
# => true

distance3 = distance1 + distance2

distance3.to_meters
# => 2000
```

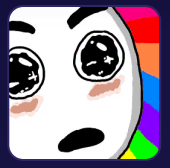

Comparable
#⟺
Data

Without value object

```
declination_radians = declination_degrees * Math::PI / 180
latitude_radians = latitude_degrees * Math::PI / 180
hour_angle_radians = hour_angle_hours * 15 * Math::PI / 180

ratio = Math.sin(declination_radians) *
        Math.sin(latitude_radians) +
        Math.cos(declination_radians) *
        Math.cos(latitude_radians) *
        Math.cos(hour_angle_radians)

altitude_radians = Math.asin(ratio)
```

Astronoby::Angle

```
ratio = declination.sin * latitude.sin +
        declination.cos * latitude.cos * hour_angle.cos

altitude = Astronoby::Angle.asin(ratio)
```



Testing

DDD ❤️ Testing

Well-defined objects

Bounded contexts

Pragmatism

Source of truth: IMCCE, NASA/JPL

Coordinate System (ICRS) : Geocentre – Equator – Astrometric J2000 – Spherical

Frame Centre

- ○ Barycentre of the Solar System
- ○ Heliocentre
- ○ Geocentre
- ○ Topocentre

Reference Plane

- ○ Equator
- ○ Ecliptic

Type of Ephemeride

- ○ Astrometric J2000
- ○ Apparent of the Date
- ○ Geometric (mean J2000)
- ○ Mean of the Date

Type of Coordinates

- ○ Spherical
- ○ Cartesian

Unit tests

Integration tests

Scientific validation

Beyond astronomy

Identify

Talk to the stakeholders

Document the vocabulary

Map the boundaries

Create bounded contexts

Add clear interfaces

Value objects

Primitive obsession

Find literals

Separate responsibilities

Split the logic

"Tell, Don't Ask"

Don't overthink

Prioritize

Stay flexible

Conclusion

What we learnt

Domain-Driven Design is hard to pronounce

DDD for managing complex domains

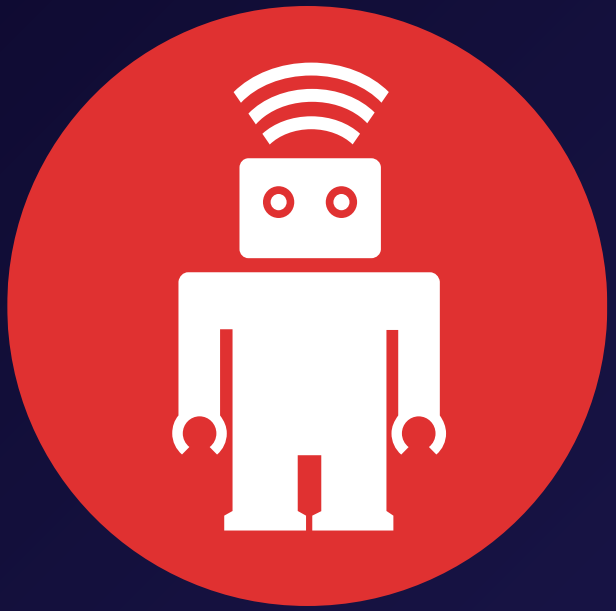
Ruby expressiveness helps

Final Thoughts

Good models illuminate complex realities

Code can be both functional and educational

Ruby deserves a place in scientific computing




Thank you