accu conference 2024

Symmetry in Code

Should We Care?

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ACCU

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Abstract

Why should we be concerned with symmetry? Symmetry is fascinating to the human mind and everyone likes objects or patterns that are in some way symmetrical. It is an interesting fact that nature often exhibits certain kinds of symmetry in the objects and phenomena in our Universe.

We have, in our minds, a tendency to accept symmetry as some kind of perfection. Yet it so often eludes us…

Let’s look at code and see what interesting properties emerge from various kinds of symmetries. A quest for the ‘Character of Code’, following Richard Feynman’s awe-inspiring take on physical laws.

We'll be looking to identify patterns in code, interested to see when such patterns exhibit some sort of symmetry that is advantageous in some way for reliability, performance, maintenance and discoverability.

About me

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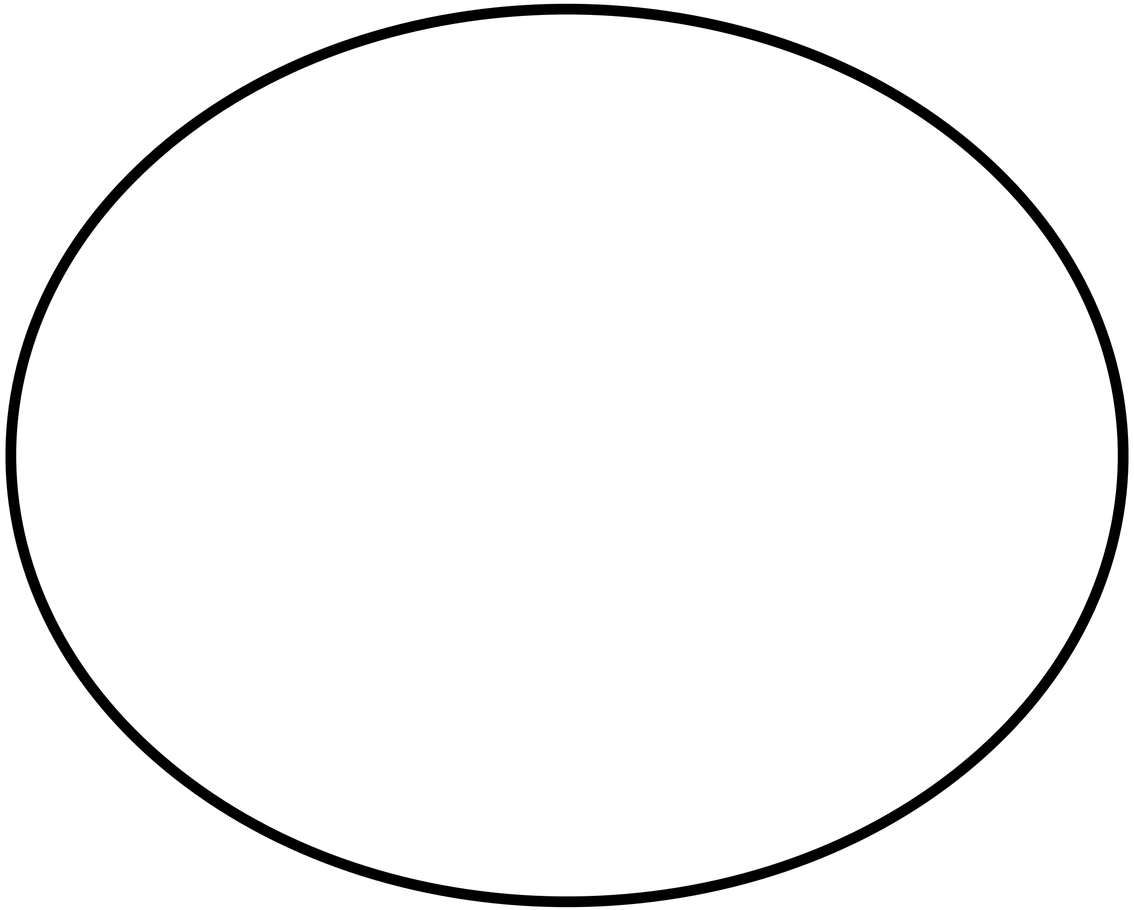
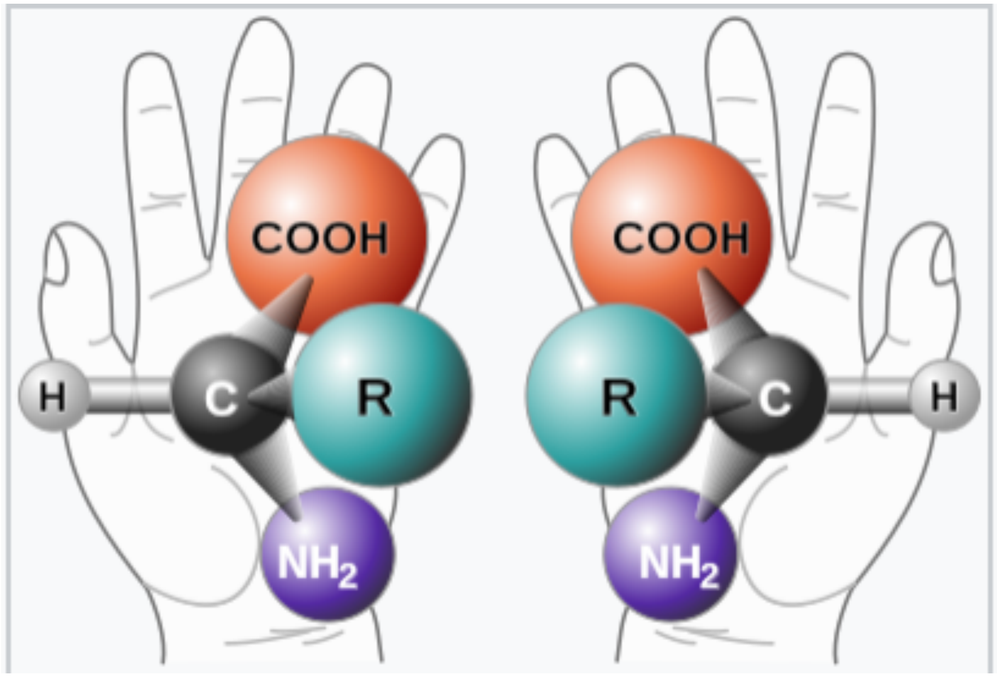
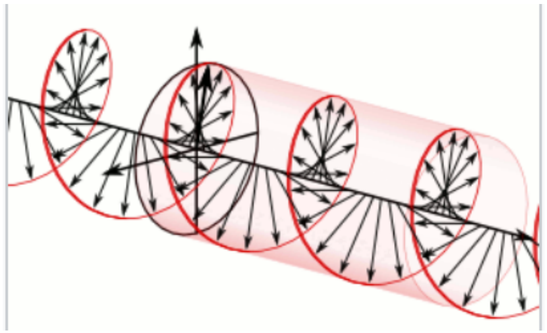
Symmetry



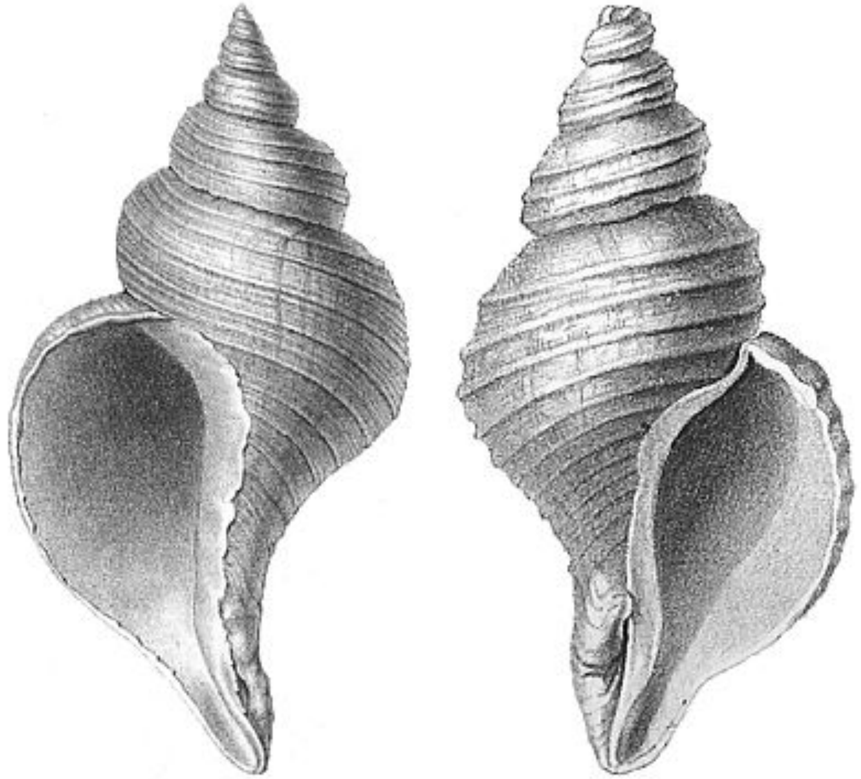
In fact, it is like the old idea of ancient GREEKS that circles were perfect, and it was rather horrible for them to believe that the planetary orbits were not circles, but only nearly circles.

Chirality



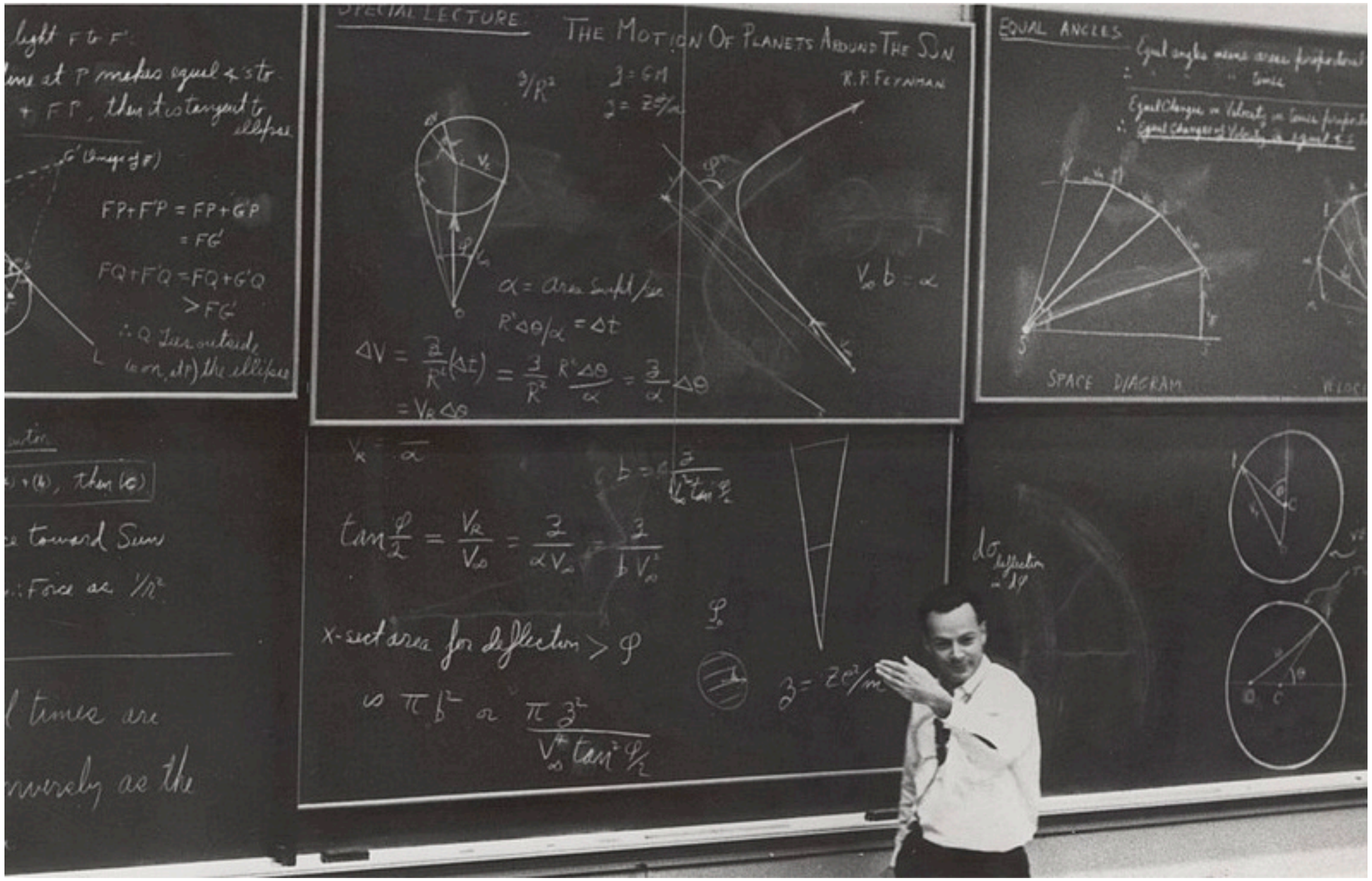


rotation of plane polarized light by chiral substances



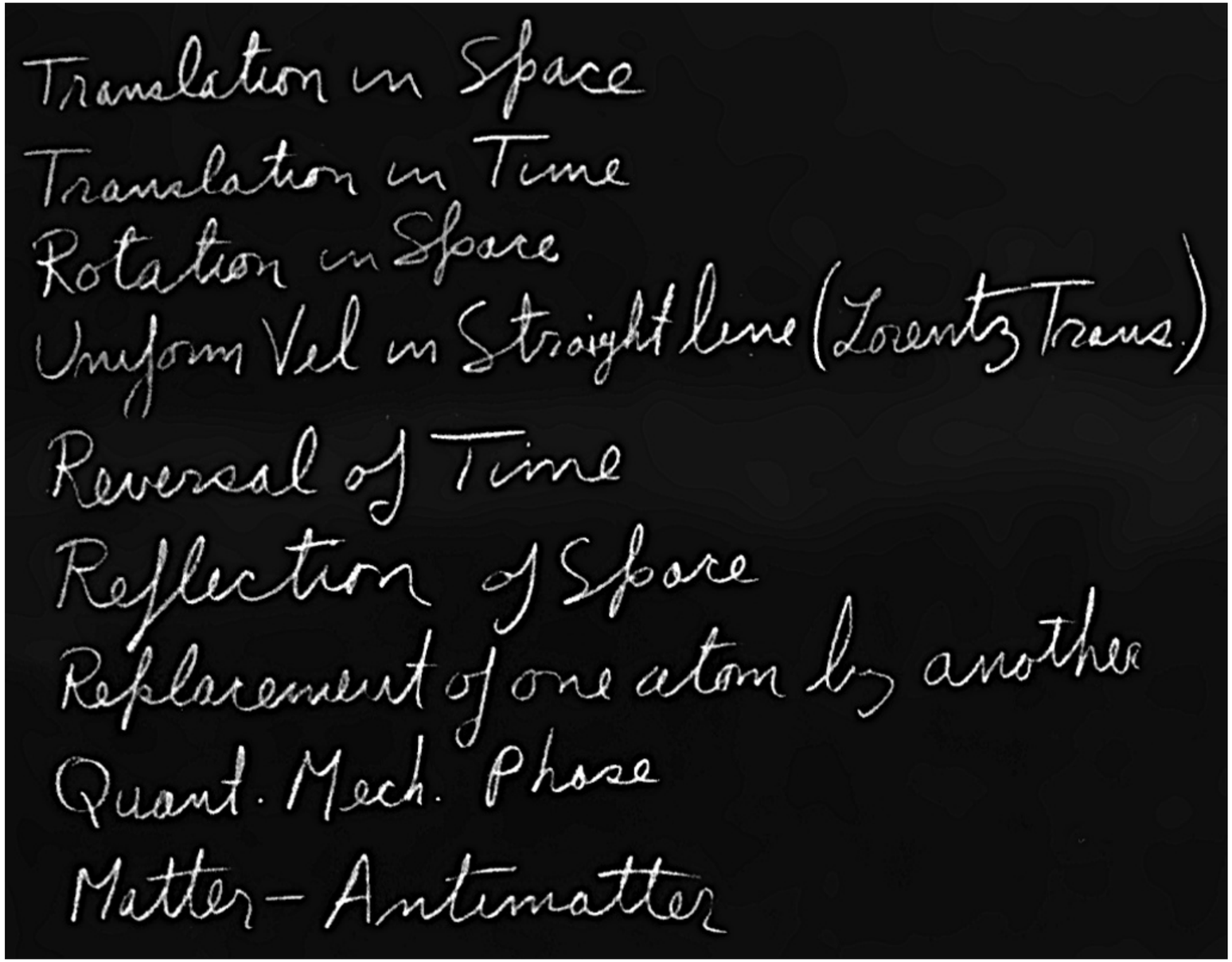
(left-handed) Neptunea angulata | (right-handed) Neptunea despecta

Richard Feynman - The Character of Physical Law (1964)



youtube.com/watch?v=kEx-gRfuhhk

Symmetry in Physical Laws



Richard Feynman - The Character of Physical Law
Part 4: Symmetry in Physical Laws

youtube.com/watch?v=tGsYbK-Chkg

Symmetry beyond geometry

Symmetry goes way beyond simple geometrical shapes & patterns.

Symmetry is not just about **observing** the properties of objects, but also for *transformations*:

- what can you **do** to a symmetrical object so it can "looks" the same

He’s the first mathematician to study symmetry for non-geometric entities (eg. equations, functions, polynomials, groups).

ted.com/talks/marcus_du_sautoy_symmetry_reality_s_riddle

Beauty, truth and ... physics?

1,527,719 views | Murray Gell-Mann | TED2007 • March 2007

"Are elegant equations more likely to be right than inelegant ones?"

“Beauty is a very successful criterion for choosing the right theory”

ted.com/talks/murray_gell_mann

$$\frac{\partial E_x}{\partial x} + \frac{\partial E_y}{\partial y} + \frac{\partial E_z}{\partial z} = 4\pi\rho \qquad (1)$$

$$\frac{\partial B_x}{\partial x} + \frac{\partial B_y}{\partial y} + \frac{\partial B_z}{\partial z} = 0 \qquad (2)$$

$$\left.\begin{aligned} \frac{\partial E_x}{\partial x} - \frac{\partial E_y}{\partial y} + \tfrac{1}{c}\dot{B}_z = 0 \\ \frac{\partial E_y}{\partial z} - \frac{\partial E_z}{\partial y} + \tfrac{1}{c}\dot{B}_x = 0 \\ \frac{\partial E_z}{\partial x} - \frac{\partial E_x}{\partial z} + \tfrac{1}{c}\dot{B}_y = 0 \end{aligned}\right\} \qquad (3)$$

$$\left.\begin{aligned} \frac{\partial B_x}{\partial y} - \frac{\partial B_y}{\partial x} - \tfrac{1}{c}\dot{E}_z = \tfrac{4\pi}{c} j_z \\ \frac{\partial B_y}{\partial z} - \frac{\partial B_z}{\partial y} - \tfrac{1}{c}\dot{E}_x = \tfrac{4\pi}{c} j_x \\ \frac{\partial B_z}{\partial x} - \frac{\partial B_x}{\partial z} - \tfrac{1}{c}\dot{E}_y = \tfrac{4\pi}{c} j_y \end{aligned}\right\} \qquad (4)$$

Original form

$$\nabla \cdot \mathbf{E} = 4\pi\rho \qquad (1)$$

$$\nabla \cdot \mathbf{B} = 0 \qquad (2)$$

$$\nabla \times \mathbf{E} + \tfrac{1}{c}\dot{\mathbf{B}} = 0 \qquad (3)$$

$$\nabla \times \mathbf{B} - \tfrac{1}{c}\dot{\mathbf{E}} = \tfrac{4\pi}{c}\mathbf{j} \qquad (4)$$

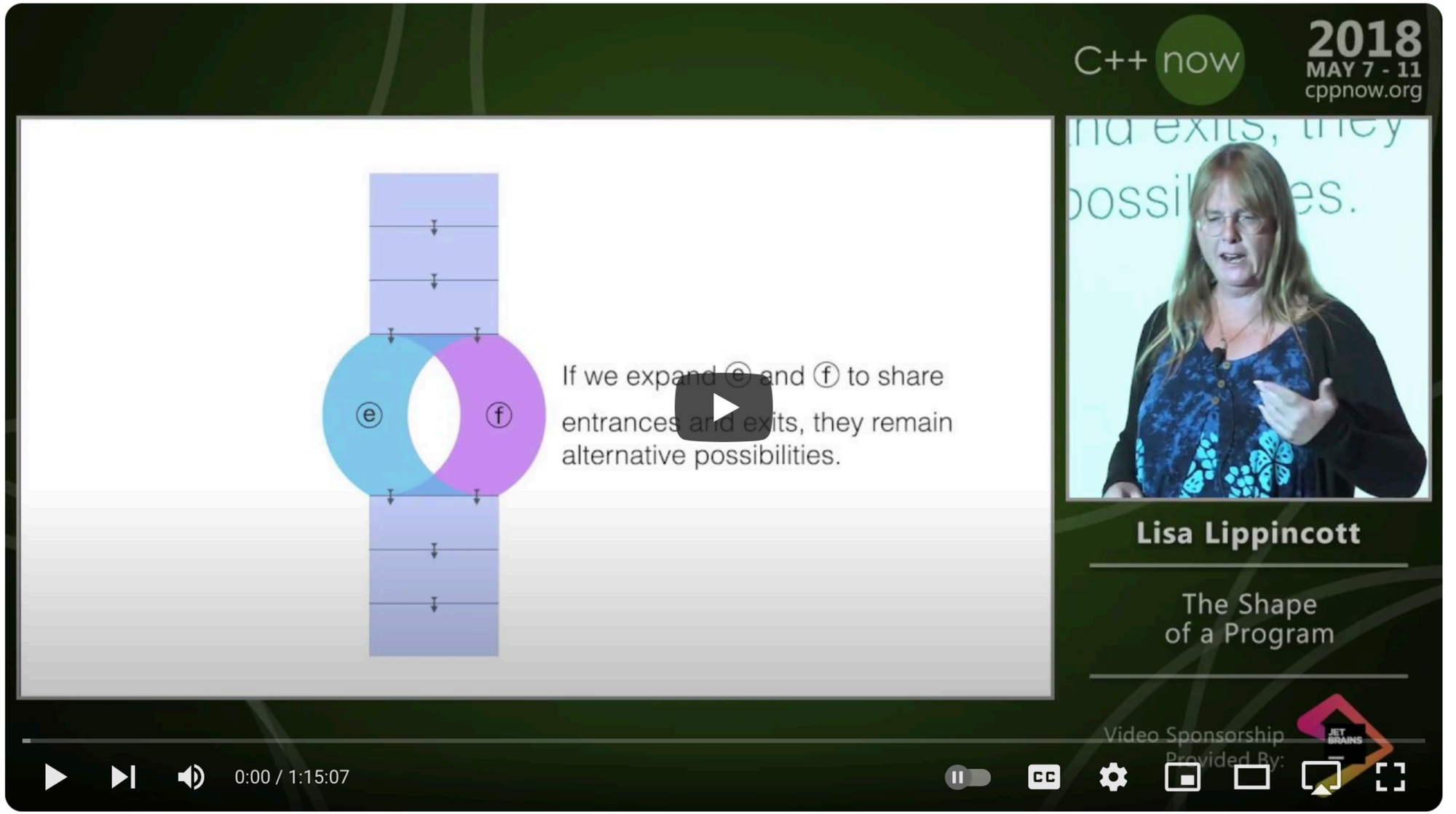
Simplified using rotational symmetry

$$\partial_\nu F^{\mu\nu} = \tfrac{4\pi}{c} j^\mu \qquad (1 \text{ and } 4)$$

$$\varepsilon^{\mu\nu\kappa\lambda}\,\partial_\nu F_{\kappa\lambda} = 0 \qquad (2 \text{ and } 3)$$

Further simplified using the symmetry of special relativity

The Shape of A Program



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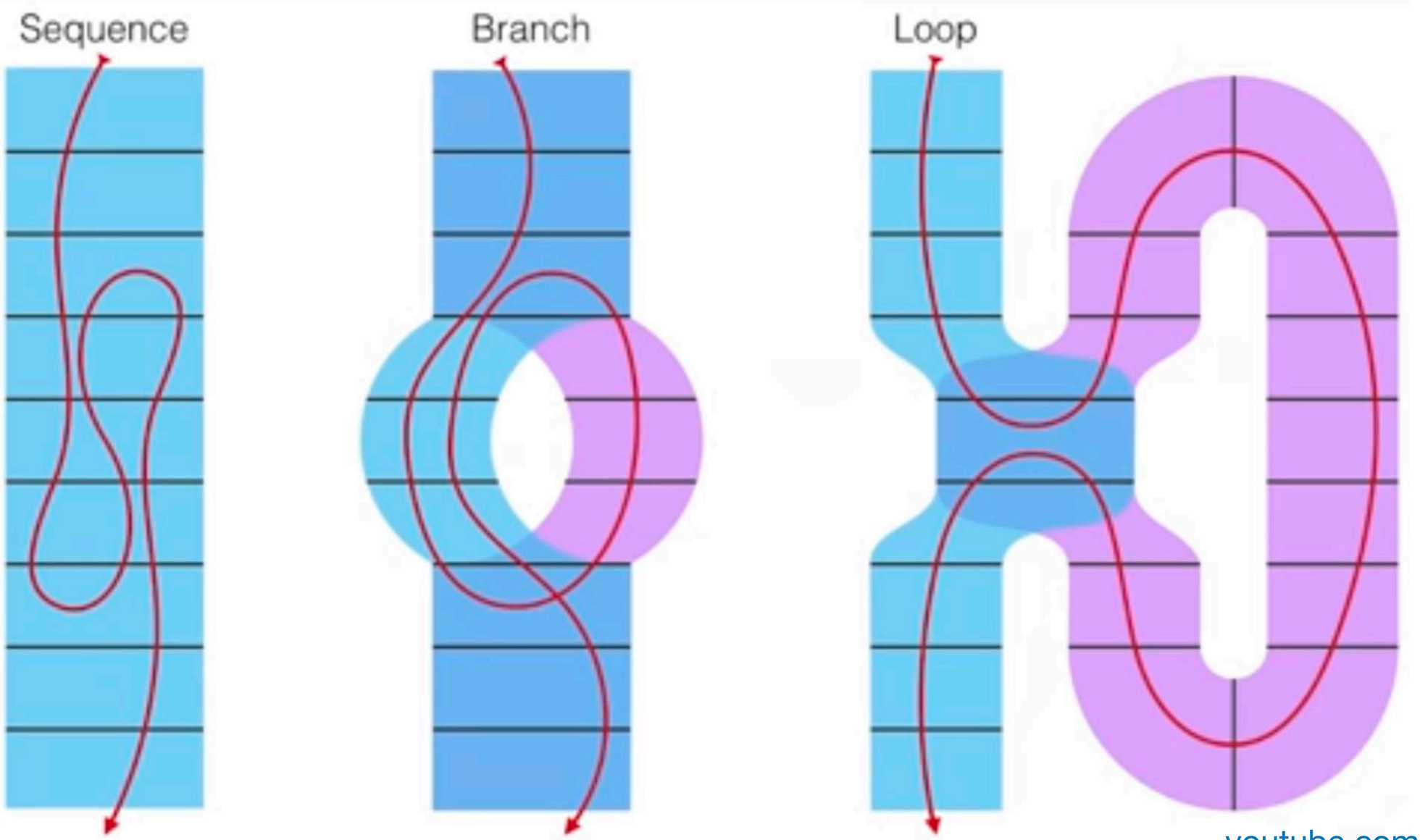
The Shape of A Program



youtube.com/watch?v=QFIOE1jKv30

Shapes of Code

The saw

fluentcpp.com/2020/01/14/the-shapes-of-code/

Shapes of Code

The paragraphs

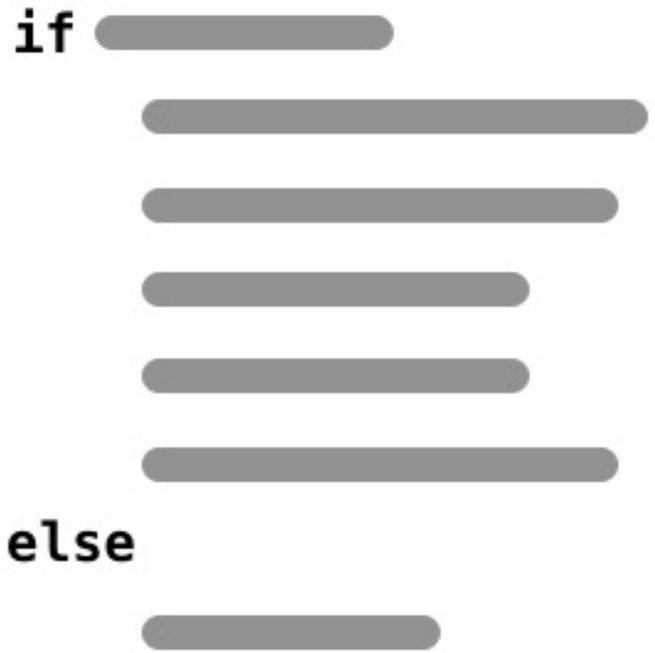
fluentcpp.com/2020/01/14/the-shapes-of-code/

Shapes of Code

The paragraphs with headers

fluentcpp.com/2020/01/14/the-shapes-of-code/

Shapes of Code

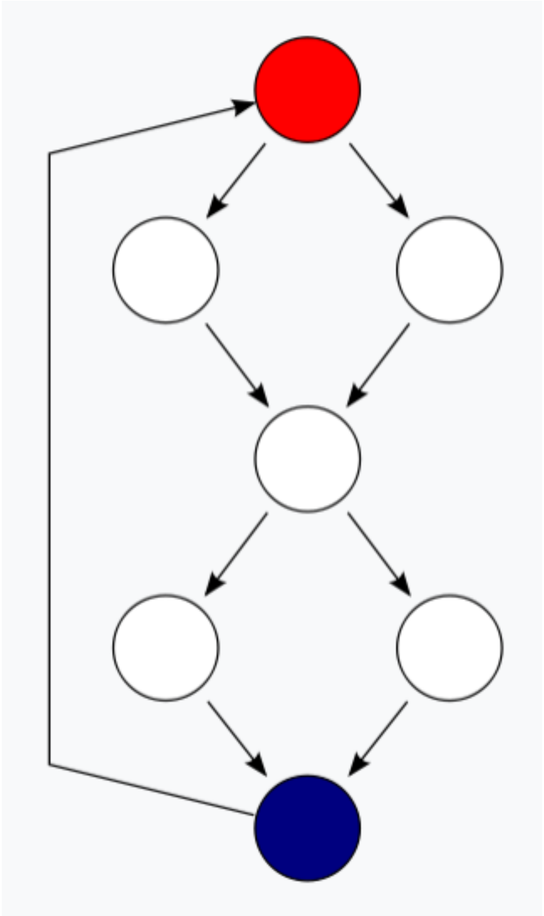


The unbalanced `if` blocks

fluentcpp.com/2020/01/14/the-shapes-of-code/

Cyclomatic Complexity

```
int func()
{
  if (c1())
    f1();
  else
    f2();

  if (c2())
    f3();
  else
    f4();
}
```



wikipedia.org/wiki/Cyclomatic_complexity

The Shape of A Program

youtube.com/watch?v=P2lxGnbDkDI

Program Complexity ?

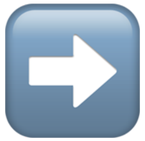
```cpp
int main()
{
    // Seed with a real random value, if available
    std::random_device r;

    // Choose a random mean between 1 and 6
    std::default_random_engine e1(r());
    std::uniform_int_distribution<int> uniform_dist(1, 6);
    int mean = uniform_dist(e1);
    std::cout << "Randomly-chosen mean: " << mean << '\n';

    // Generate a normal distribution around that mean
    std::seed_seq seed2{r(), r(), r(), r(), r(), r(), r(), r()};
    std::mt19937 e2(seed2);
    std::normal_distribution<> normal_dist(mean, 2);

    std::map<int, int> hist;
    for (int n = 0; n < 10000; ++n) {
        ++hist[std::round(normal_dist(e2))];
    }
    std::cout << "Normal distribution around " << mean << ":\n";
    for (auto p : hist) {
        std::cout << std::fixed << std::setprecision(1)
                  << std::setw(2) << p.first << ' ' <<
                  std::string(p.second/200, '*') << '\n';
    }
}
```

Program Complexity ?

```
HRESULT BasicFileOpen()
{
    // CoCreate the File Open Dialog object.
    IFileDialog *pfd = NULL;
    HRESULT hr = CoCreateInstance(CLSID_FileOpenDialog, NULL, CLSCTX_INPROC_SERVER, IID_PPV_ARGS(&pfd));
    if (SUCCEEDED(hr)) {
        // Create an event handling object, and hook it up to the dialog.
        IFileDialogEvents *pfde = NULL;
        hr = CDialogEventHandler_CreateInstance(IID_PPV_ARGS(&pfde));
        if (SUCCEEDED(hr)) {
            // Hook up the event handler.
            DWORD dwCookie;
            hr = pfd->Advise(pfde, &dwCookie);
            if (SUCCEEDED(hr)) {
                // Set the options on the dialog.
                DWORD dwFlags;

                // Before setting, always get the options first in order
                // not to override existing options.
                hr = pfd->GetOptions(&dwFlags);
                if (SUCCEEDED(hr)) {
                    // In this case, get shell items only for file system items.
                    hr = pfd->SetOptions(dwFlags | FOS_FORCEFILESYSTEM);
                    if (SUCCEEDED(hr)) {
                        // Set the file types to display only.
                        // Notice that this is a 1-based array.
                        hr = pfd->SetFileTypes(ARRAYSIZE(c_rgSaveTypes), c_rgSaveTypes);
                        if (SUCCEEDED(hr)) {
                            // Set the selected file type index to Word Docs for this example.
                            hr = pfd->SetFileTypeIndex(INDEX_WORDDOC);
                            if (SUCCEEDED(hr)) {
                                // Set the default extension to be ".doc" file.
                                hr = pfd->SetDefaultExtension(L"doc;docx");
                                if (SUCCEEDED(hr)) {
                                    // Show the dialog
                                    hr = pfd->Show(NULL);
                                    if (SUCCEEDED(hr)) {
                                        // Obtain the result once the user clicks
                                        // the 'Open' button.
                                        // The result is an IShellItem object.
                                        IShellItem *psiResult;
                                        hr = pfd->GetResult(&psiResult);
                                        if (SUCCEEDED(hr)) {
                                            // We are just going to print out the
                                            // name of the file for sample sake.
                                            PWSTR pszFilePath = NULL;
                                            hr = psiResult->GetDisplayName(SIGDN_FILESYSPATH, &pszFilePath);
                                            if (SUCCEEDED(hr))
                                            {
                                                TaskDialog(NULL, NULL, L"CommonFileDialogApp", pszFilePath, NULL, TDCBF_OK_BUTTON, TD_INFORMATION_ICON, NULL);
                                                CoTaskMemFree(pszFilePath);
                                            }
                                            psiResult->Release();
                                        }
                                    }
                                }
                            }
                        }
                    }
                }
                // Unhook the event handler.
                pfd->Unadvise(dwCookie);
            }
            pfde->Release();
        }
        pfd->Release();
    }
    return hr;
}
```

Reduce Complexity

```
void DoThing(int index)
{
    if (IsValidIndexOfOtherThing(index))
    {
        if (CanDoSomethingWithNumber(index))
        {
            if (CheckSomethingCriticalAboutValue(index))
            {
                for (auto const& value : GetData(index))
                {
                    switch (value % 3)
                    {
                    case 0:
                        PrintFoo(value);
                        break;

                    case 1:
                        PrintBar(value);
                        break;

                    case 2:
                        PrintBaz(value);
                        break;
                    }
                }
            }
        }
    }
}
```



```
void DoThing(int index)
{
    if (!IsValidIndexOfOtherThing(index))
    {
        return;
    }

    if (!CanDoSomethingWithNumber(index))
    {
        return;
    }

    if (!CheckSomethingVeryCriticalAboutValue(index))
    {
        return;
    }

    for (auto const& value : GetValuesSimilarTo(index))
    {
        ProcessValue(value);
    }
}
```

Flatten, using guards

Guard Pattern

```rust
/// e.g., "my_key: 123"
pub fn key_num<'a>(item: &'a str) → Result<(&'a str, i32) > {
  if let Some((key, val)) = item split_once(':') {
    if let Ok(val) = val.trim().parse::<i32>() {
      Ok((key, val))
    } else {
      Err(Error::Static("Can't parse integer"))
    }
  } else {
    Err(Error::Static("Invalid format"))
  }
}
```

Guard Pattern

```rust
/// e.g., "my_key: 123"
pub fn key_num<'a>(item: &'a str) → Result<(&'a str, i32) > {
  let Some((key, val)) = item split_once(':') else {
    return Err(Error::Static("Invalid format"));
  };

  let Ok(val) = val.trim().parse::<i32>() else {
    return Err(Error::Static("Can't parse integer"));
  };

  Ok((key, val))
}
```

Guard Pattern

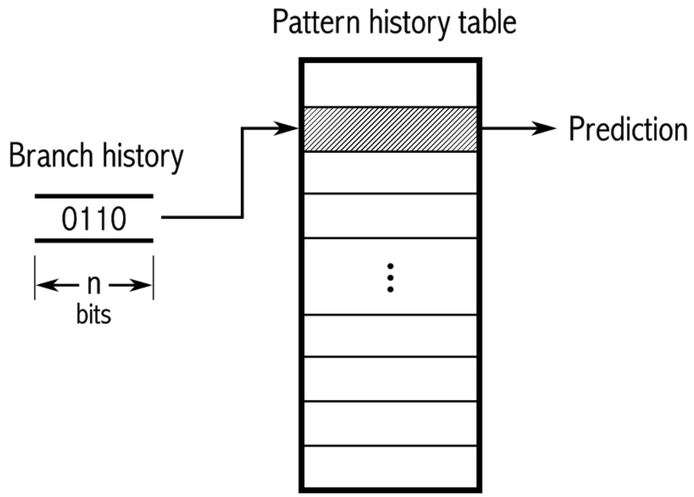
```
func getMeaningOfLife() -> Int? {
  42
}

func printMeaningOfLife() {
  if let name = getMeaningOfLife() {
    print(name)
  }
}
```

Guard Pattern

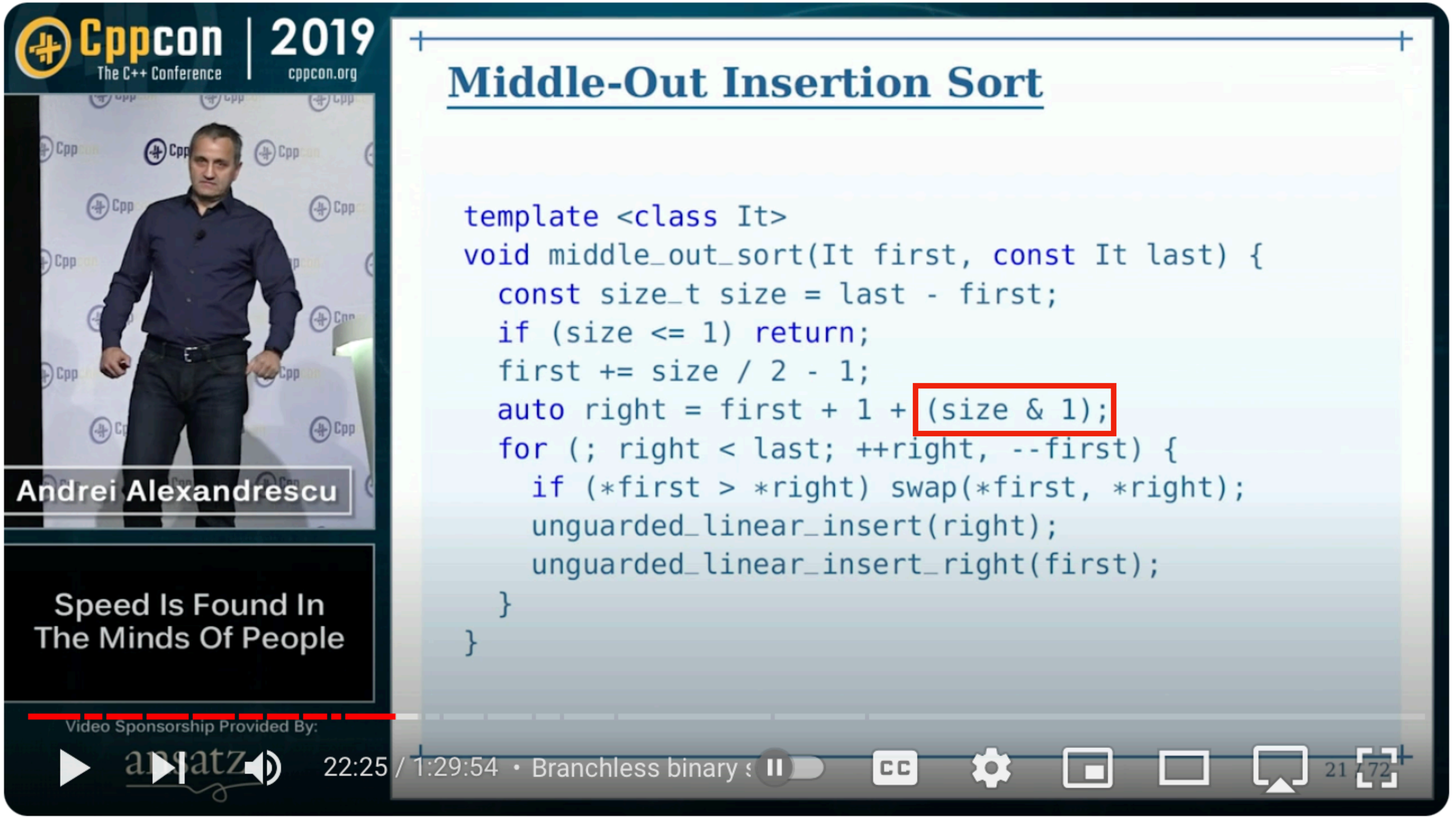
```
func printMeaningOfLife() {
  guard let name = getMeaningOfLife() else {
    return
  }

  print(name)
}
```

Left Leaning ⬅️

Code that is left-leaning is fast



Left Leaning ⬅️



youtube.com/watch?v=FJJTYQYB1JQ

Left Leaning ⬅️

“Code that is left-leaning is fast”

- Andrei Alexandrescu

```
auto right = first + 1 + (size & 1);
```

🚫

```
if (size & 1) right++;
```

Position in the middle of the array - but differently **if** we have odd or even number of elements.

But there is no `if` statement!

Integrating the conditional within the arithmetic, to avoid branching. (no jumps!

Be Deliberate

Incidental vs. deliberate symmetry

Should We Care?

We should be looking to identify patterns in code,
to see when such constructs exhibit some sort of symmetry
that is advantageous in some way for:

- reliability
- performance
- maintenance/extensibility
- discoverability

++

Incrementing variables in for-loops:

`i++`

- overused
- nonsensical
- imbalanced

`i-=-1`

- hipster
- expressive
- symmetric

credit: *probably* Ólafur Waage

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