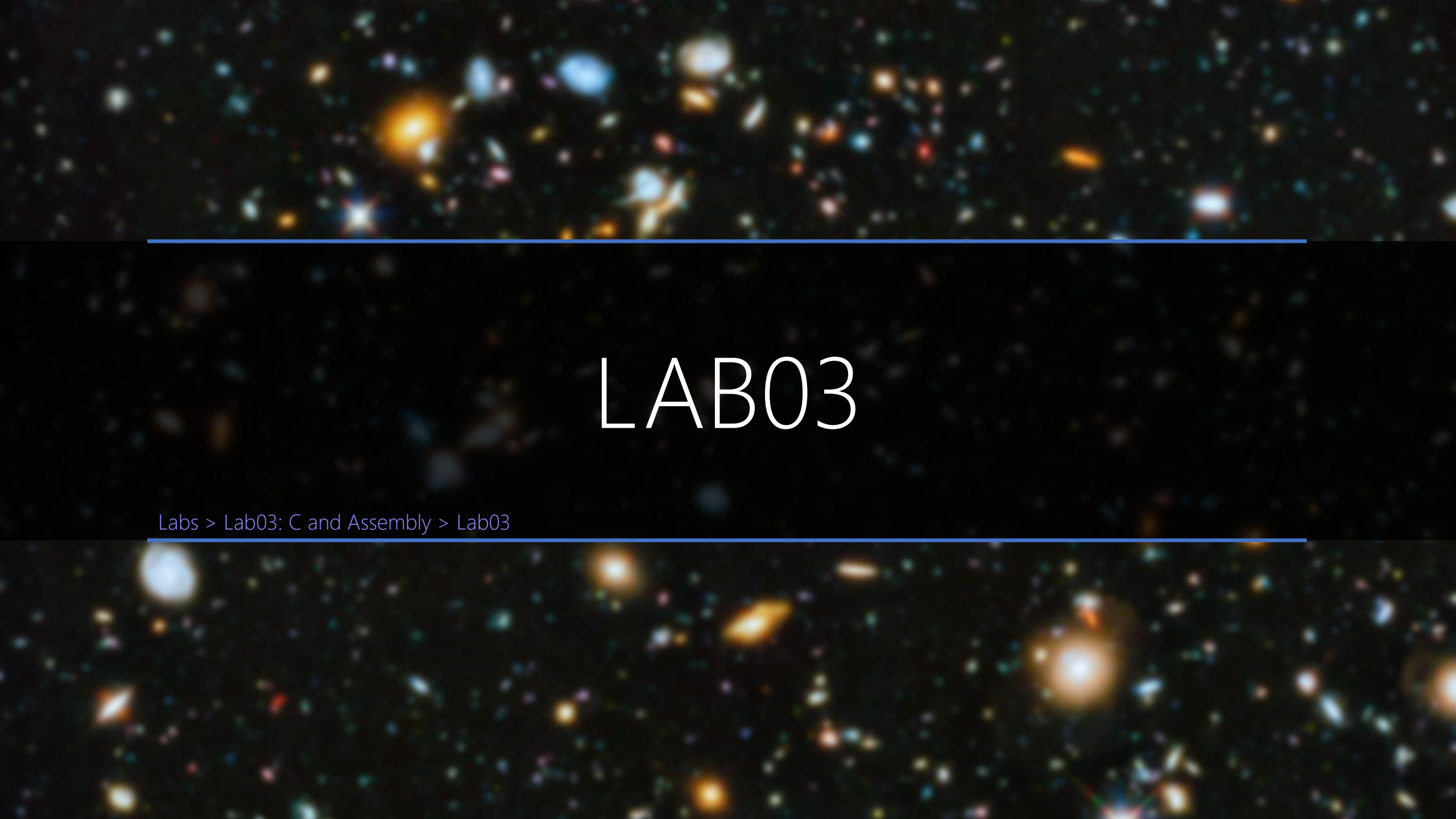
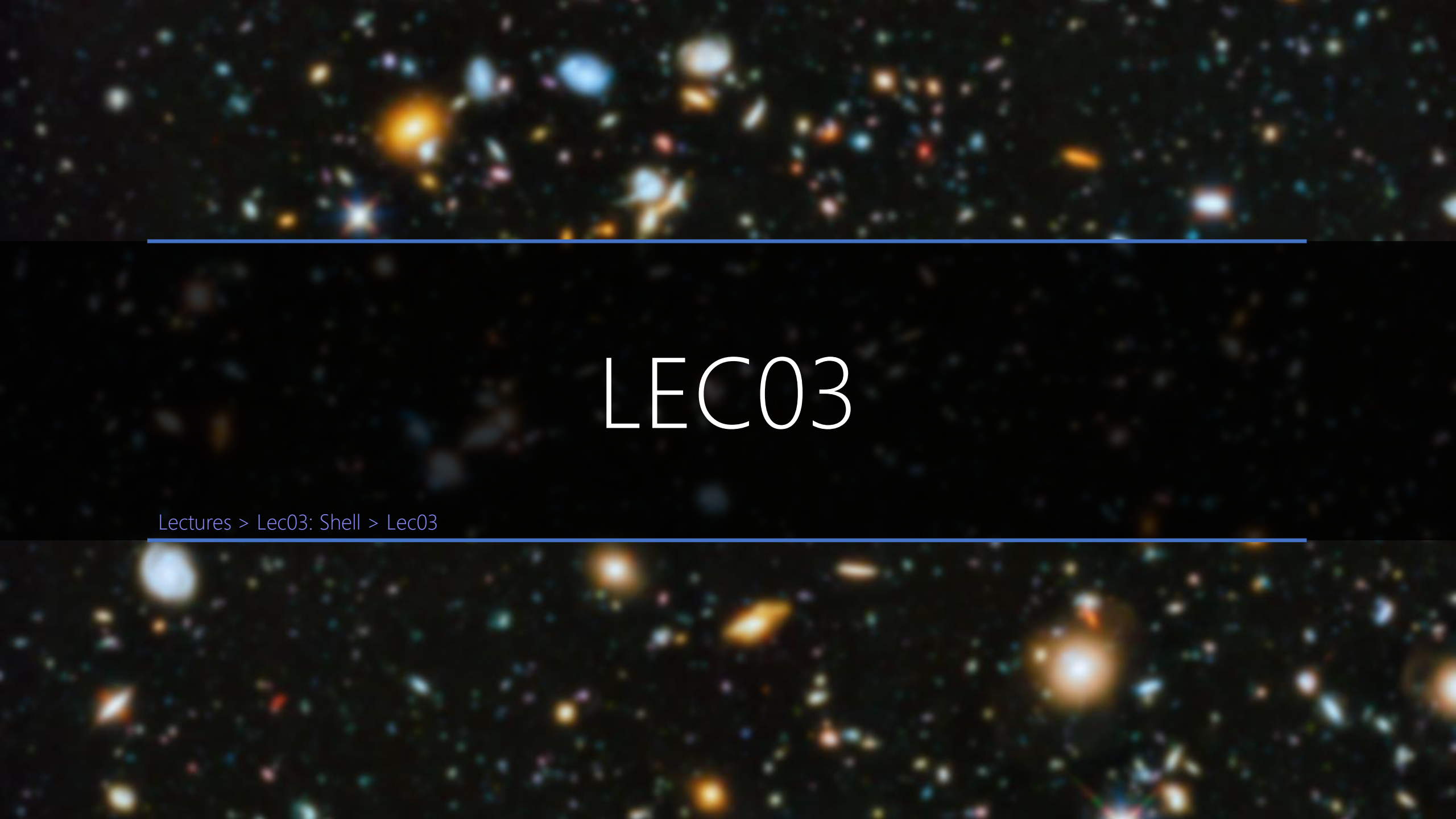

MATT DAMON
THE
BOURNE ULTIMATUM



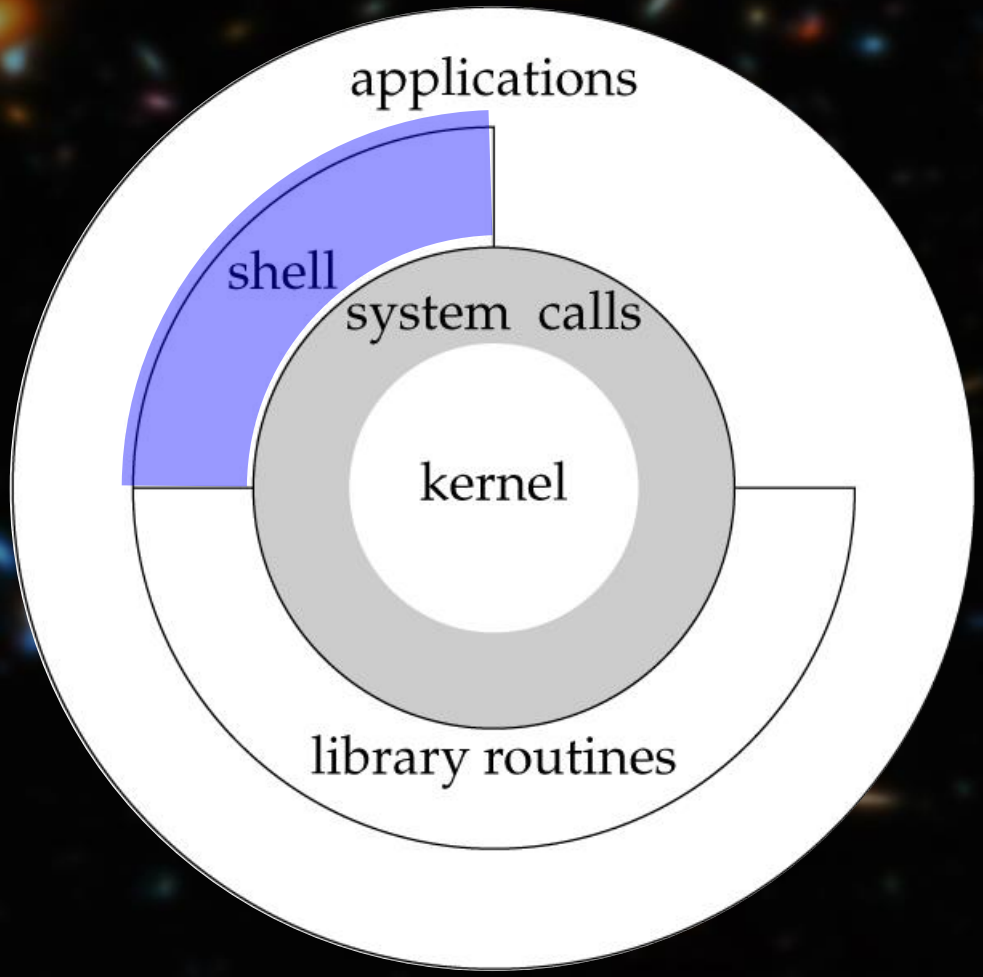
# LAB03

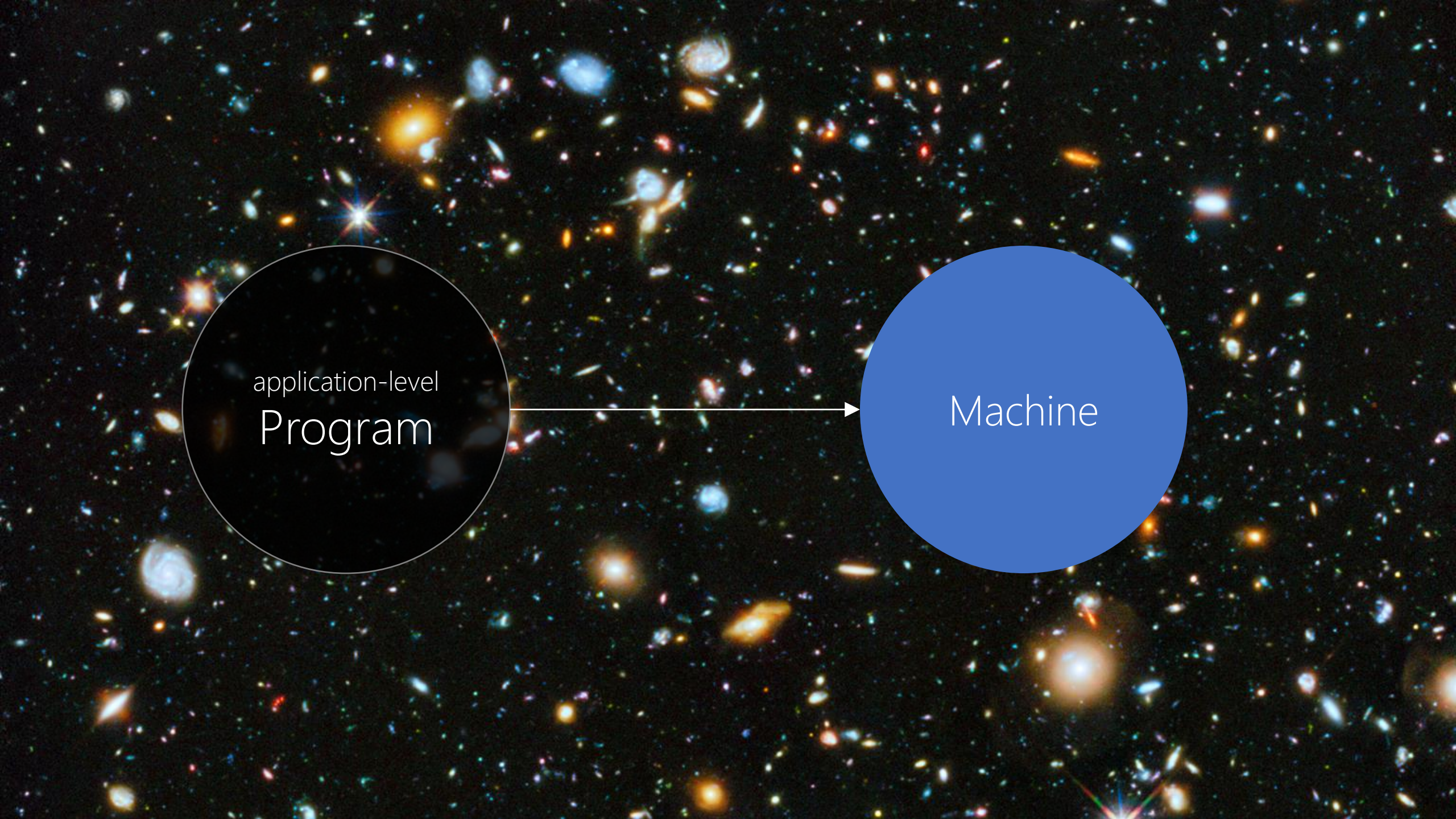
Labs > Lab03: C and Assembly > Lab03



# LEC03

Lectures > Lec03: Shell > Lec03


applications
shell
system calls
kernel
library routines


application-level
Program
Machine

# Know the Computer System Status

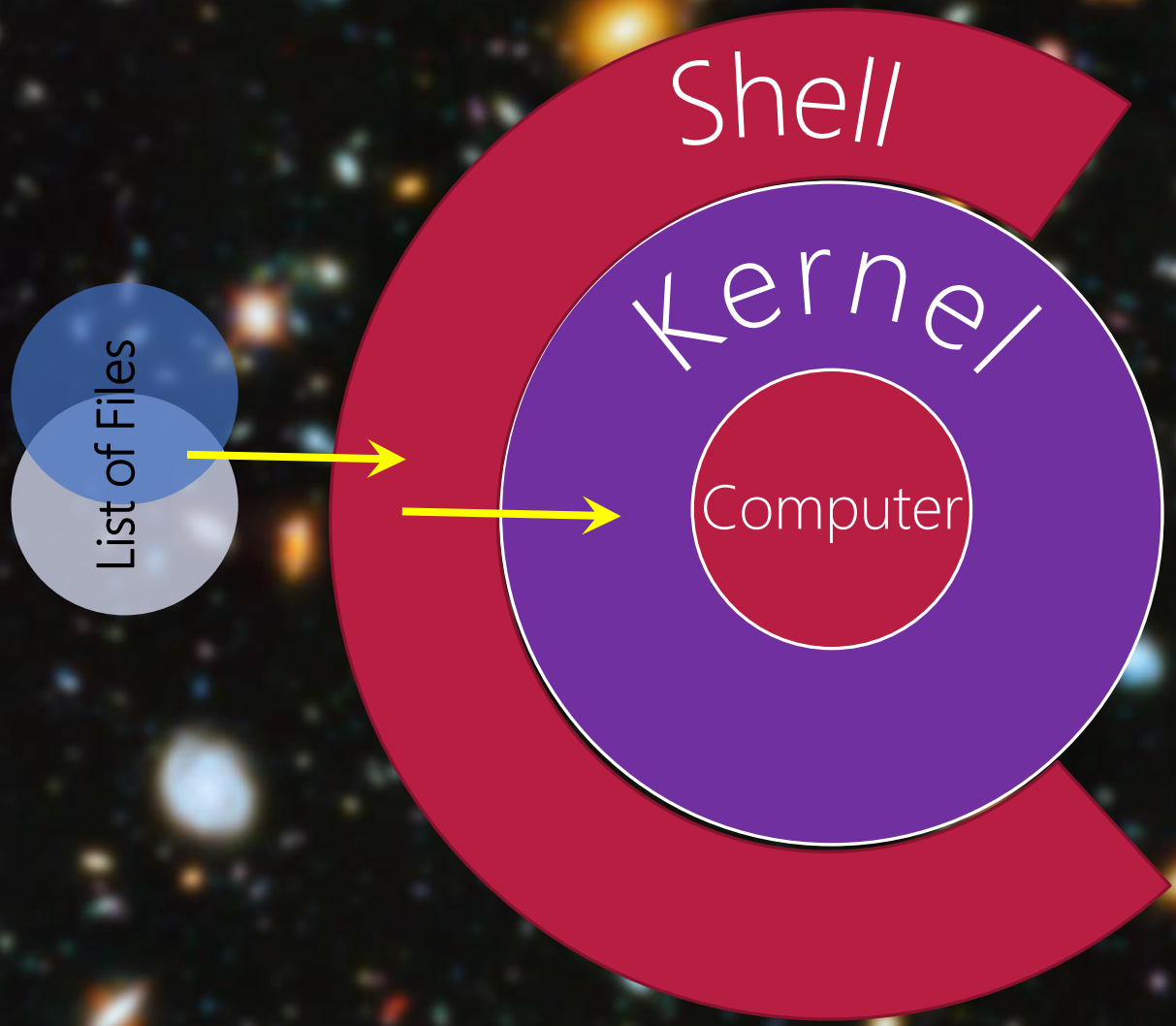
Is there any other programs?
Is there any other files?
What are the files?
What are the files' sizes?
Are there any hidden files?
Does memory/HDD have free space?
And many other questions.

# Who knows the answers?

Oracle
Programmer
Shell
Kernel
Processor

# How to ask?

English Language
Opcodes
C program → Assembly → Opcodes




# Computer

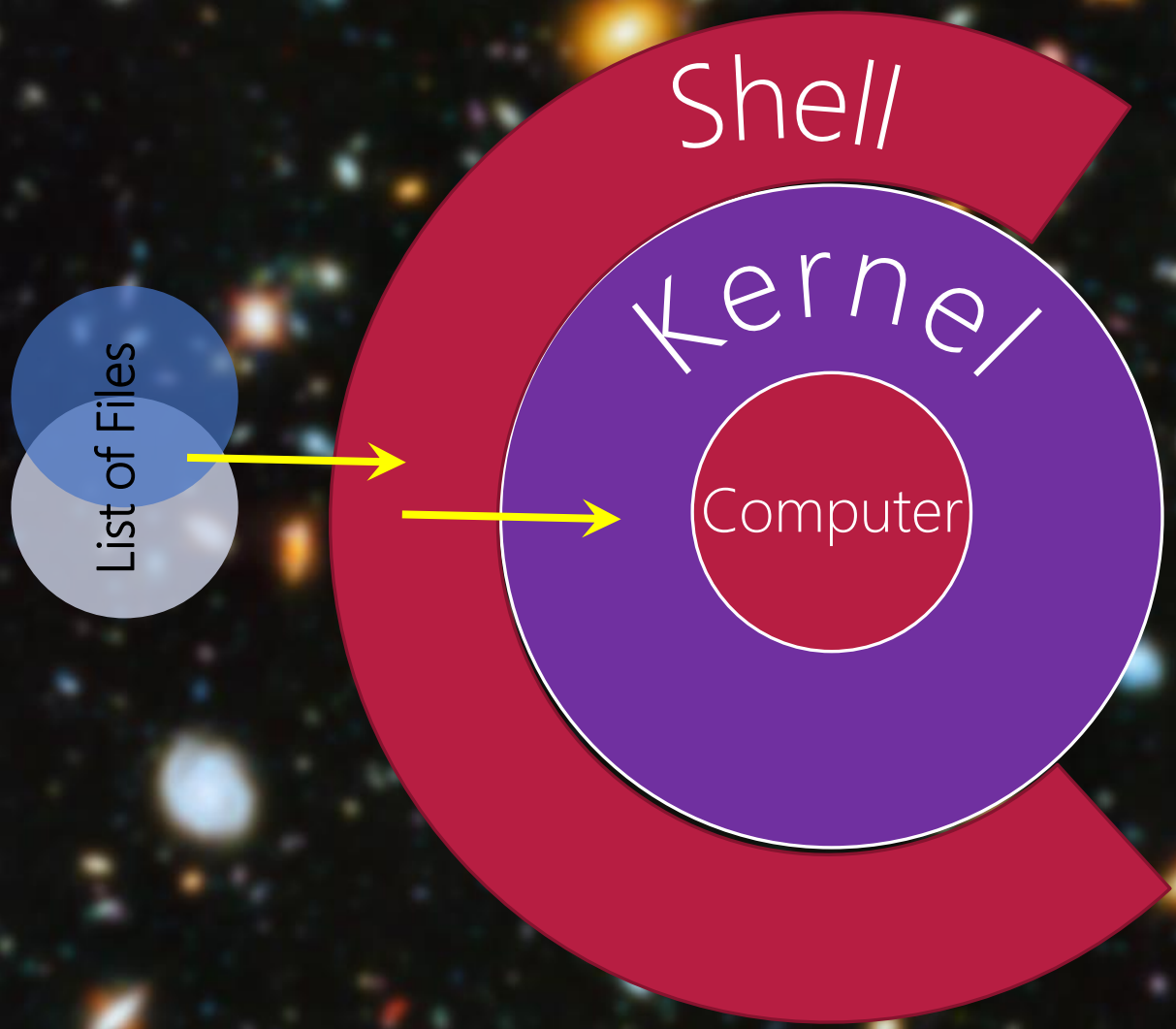
Memory

Kernel
File System

Shell

Bus

Processor




# Computer

Memory

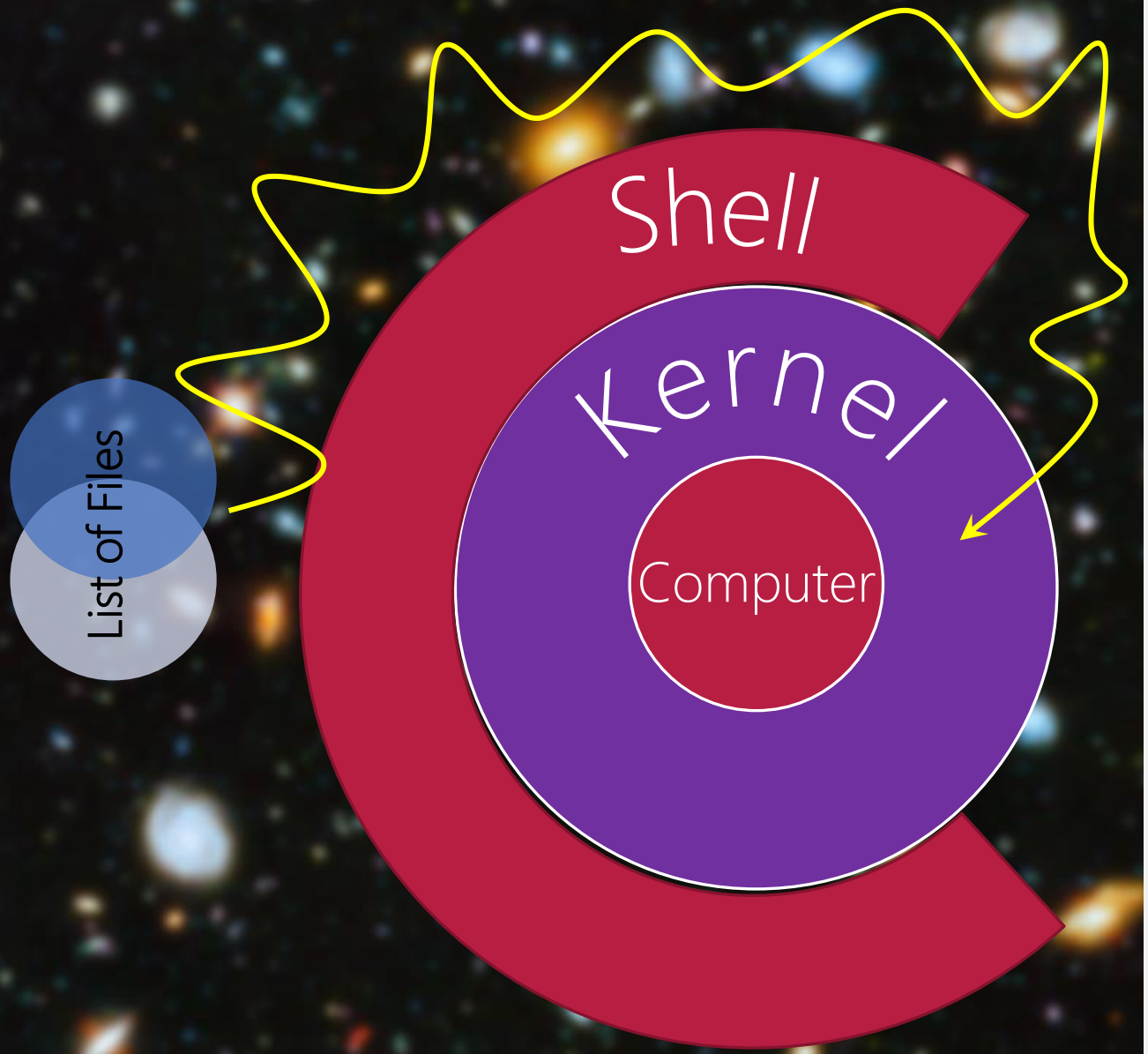
Kernel
File System

Shell

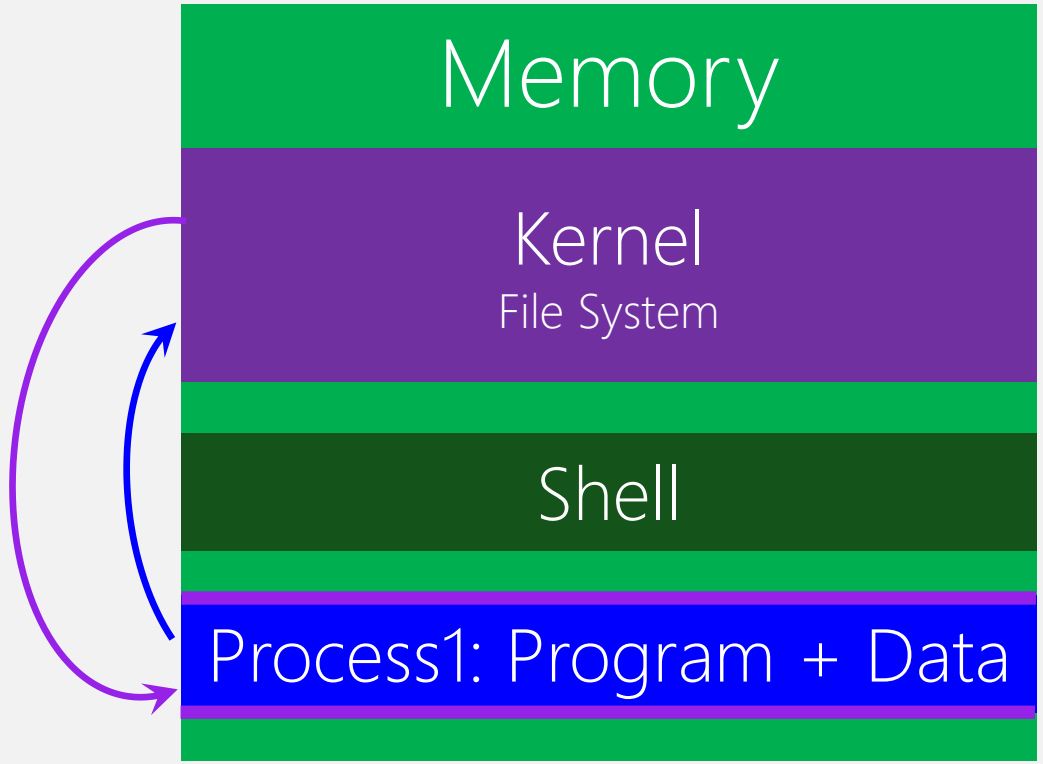
Process1: Program + Data

Bus

Processor

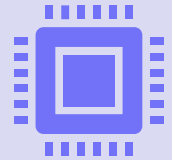



# Computer

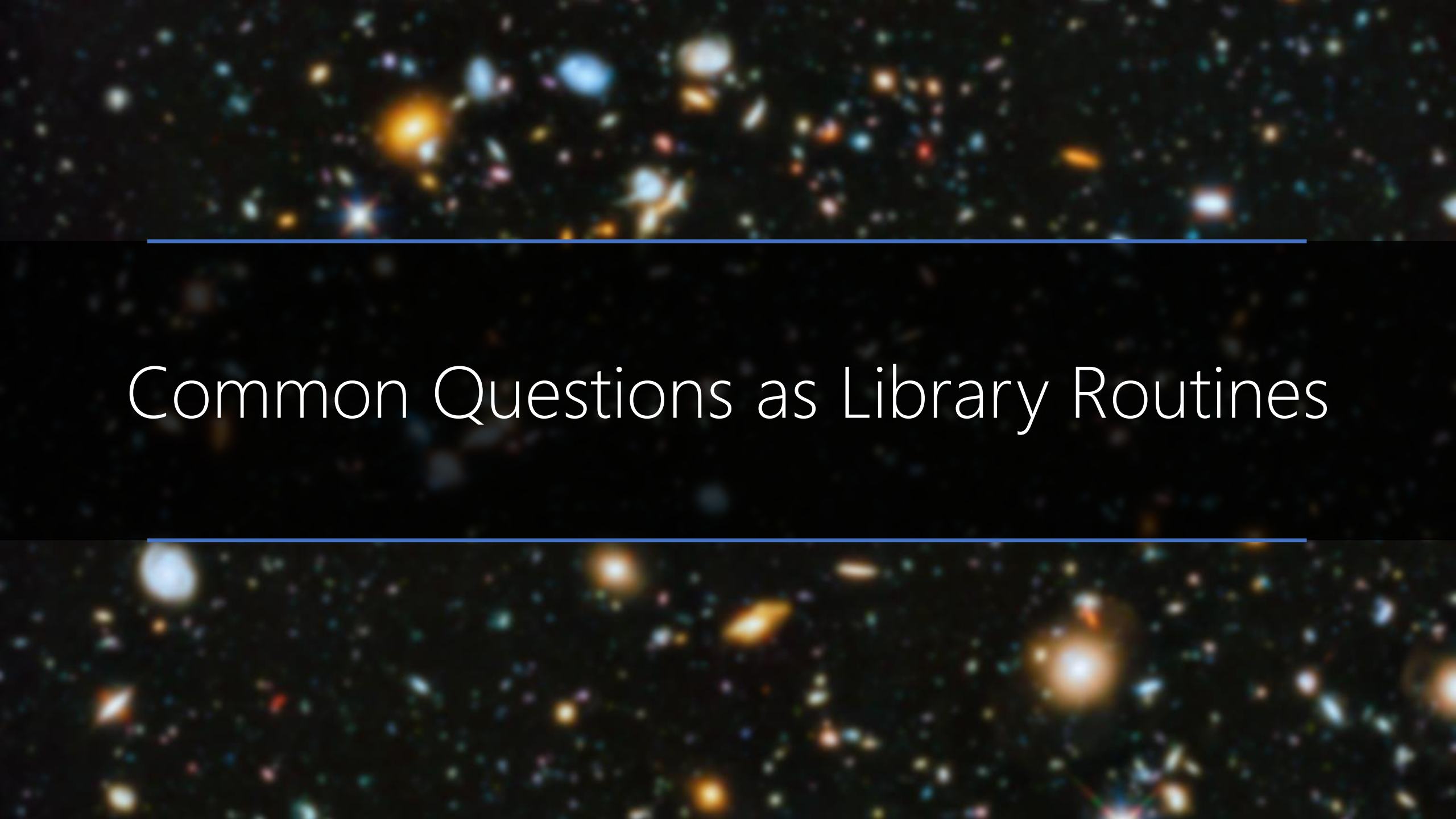



Bus

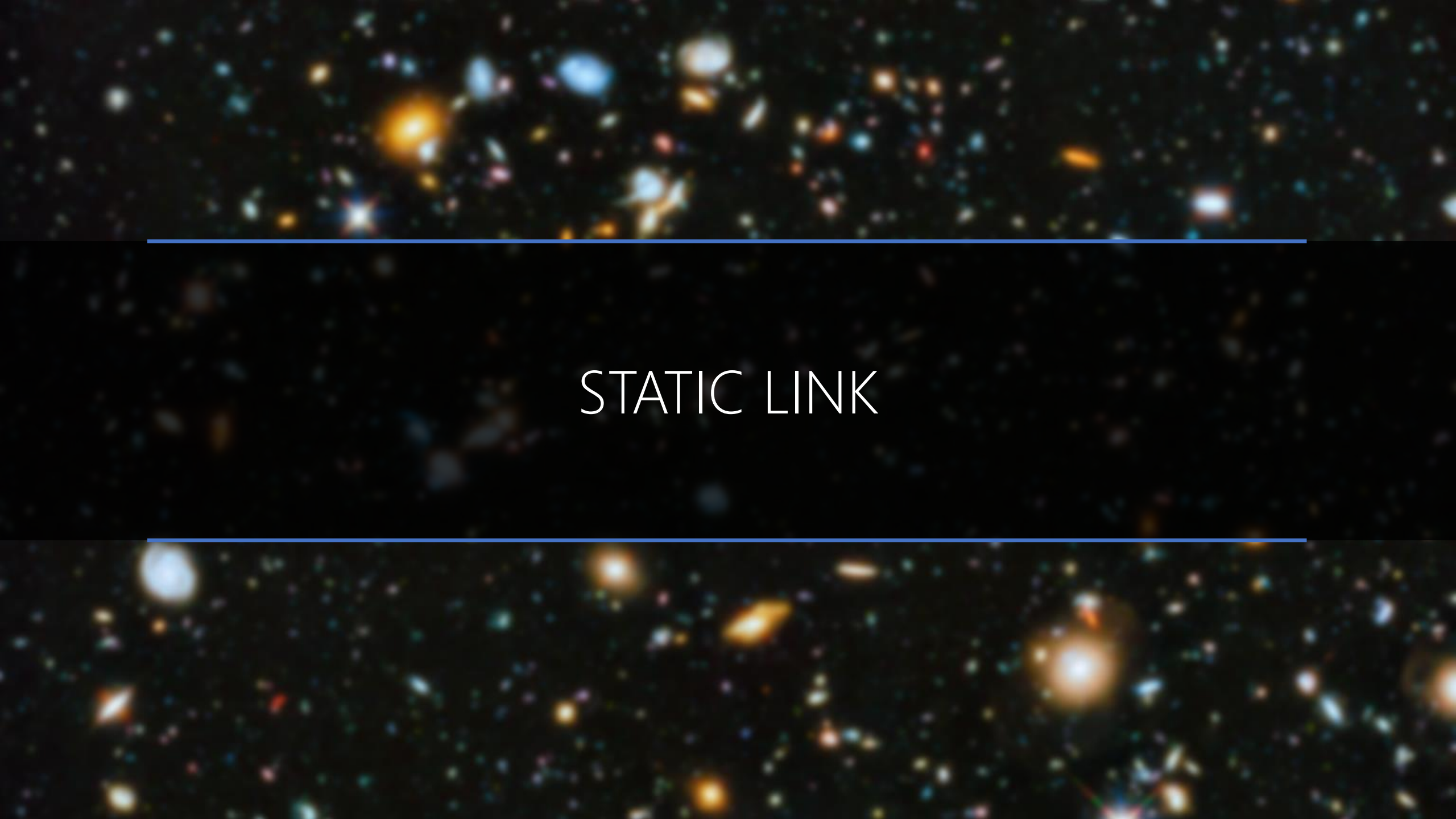
Processor



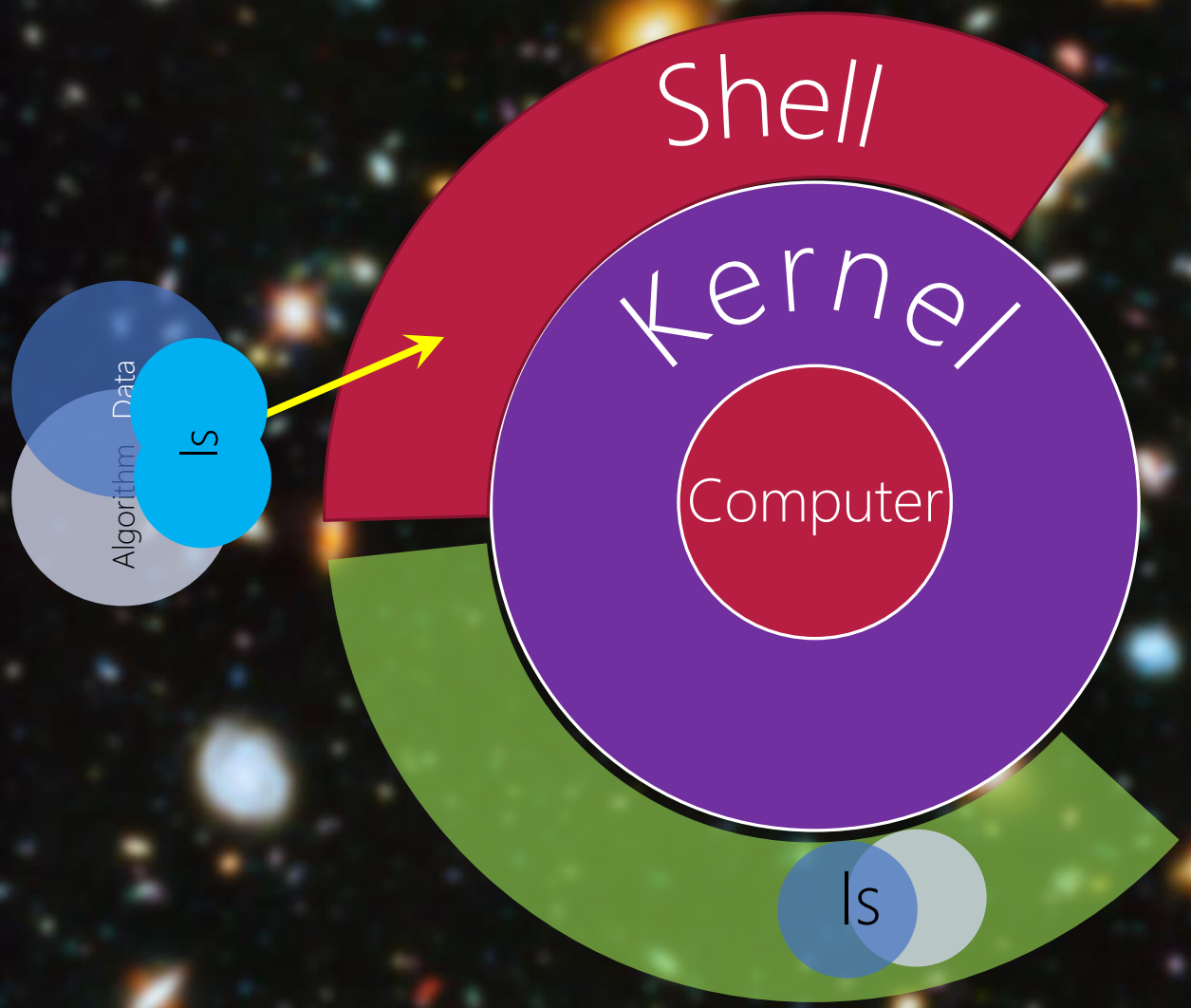
https://github.com/wertarbyte/coreutils/blob/master/src/ls.c



# Common Questions as Library Routines



# STATIC LINK




# Computer

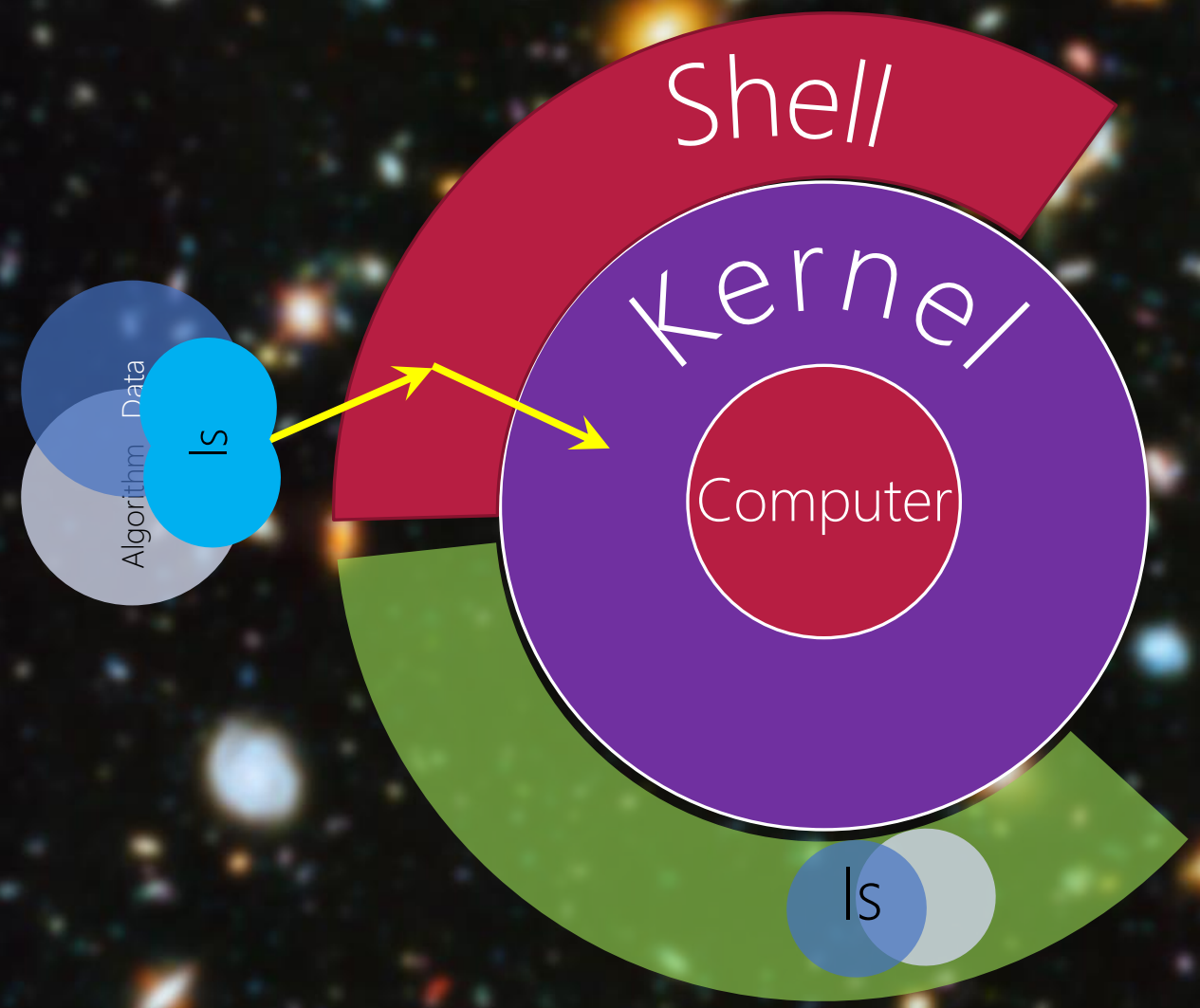
Memory

Kernel

Shell

Bus

Processor




# Computer

Memory

Kernel

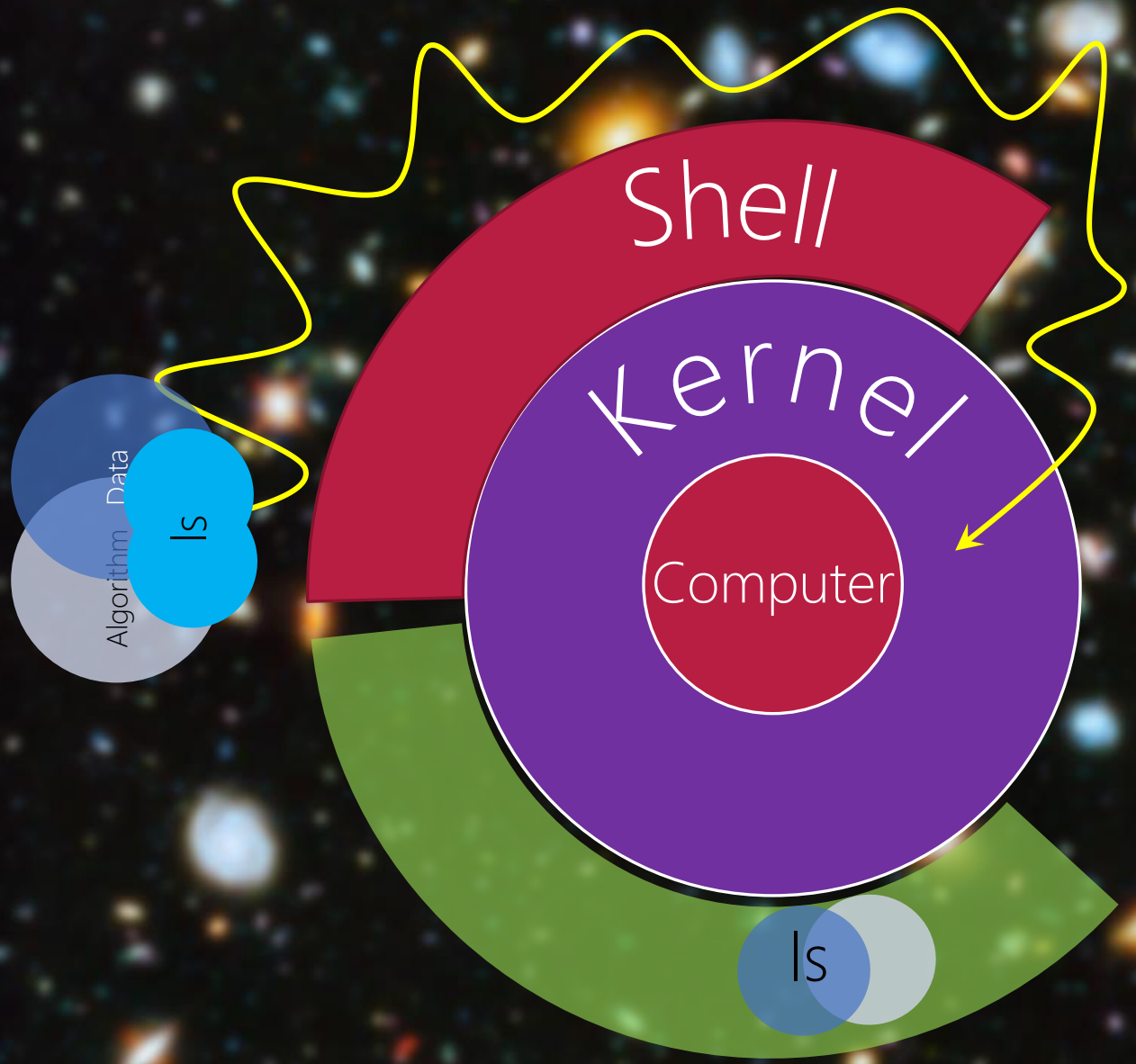
Shell

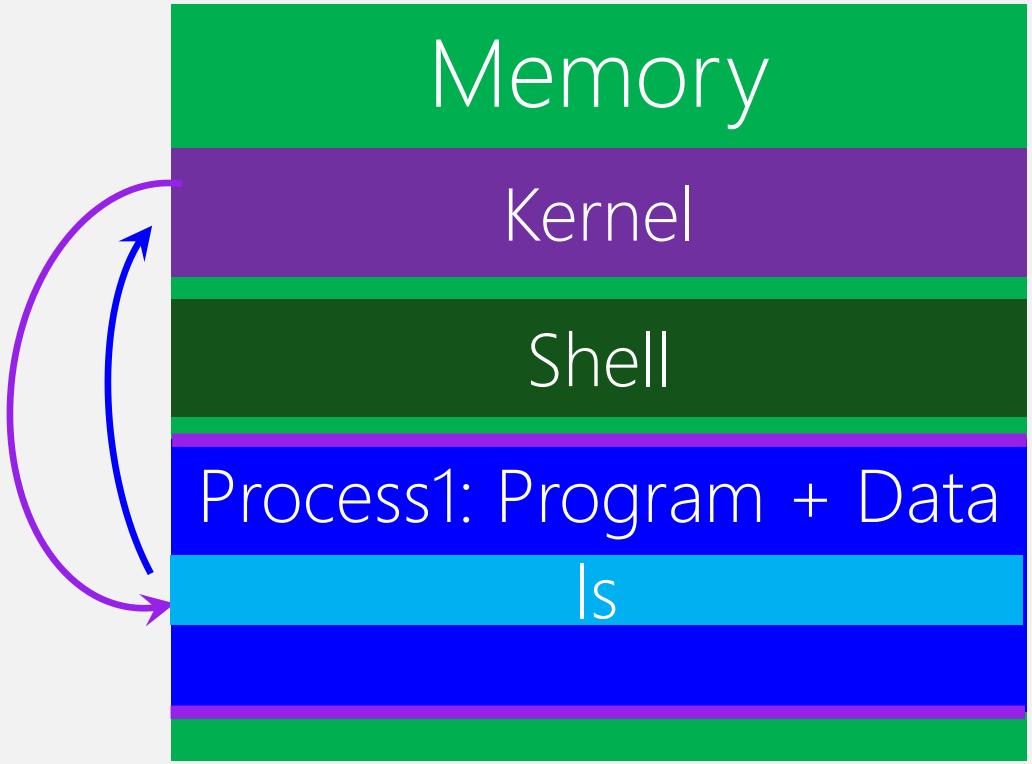
Process1: Program + Data

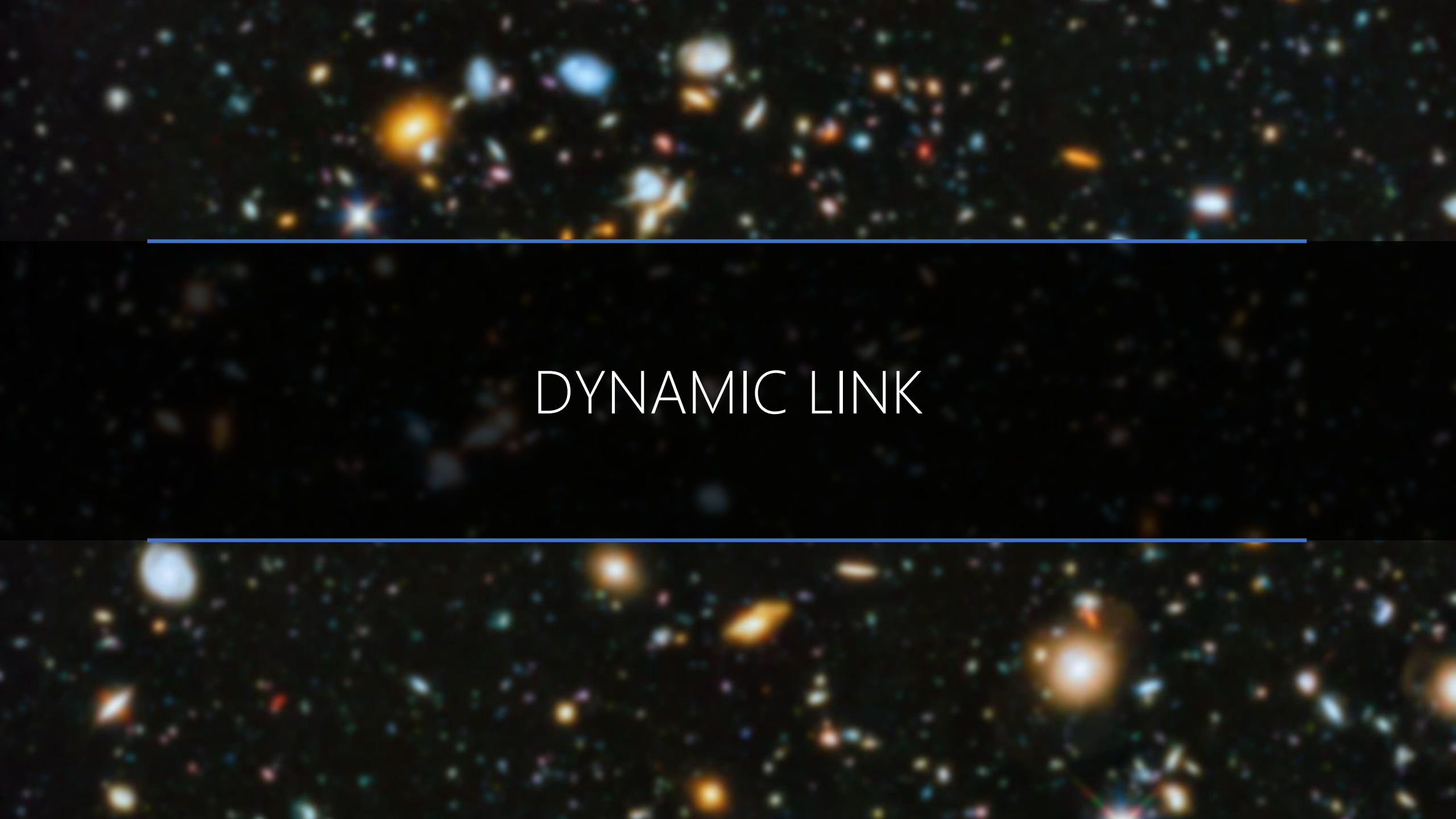
Is

Bus

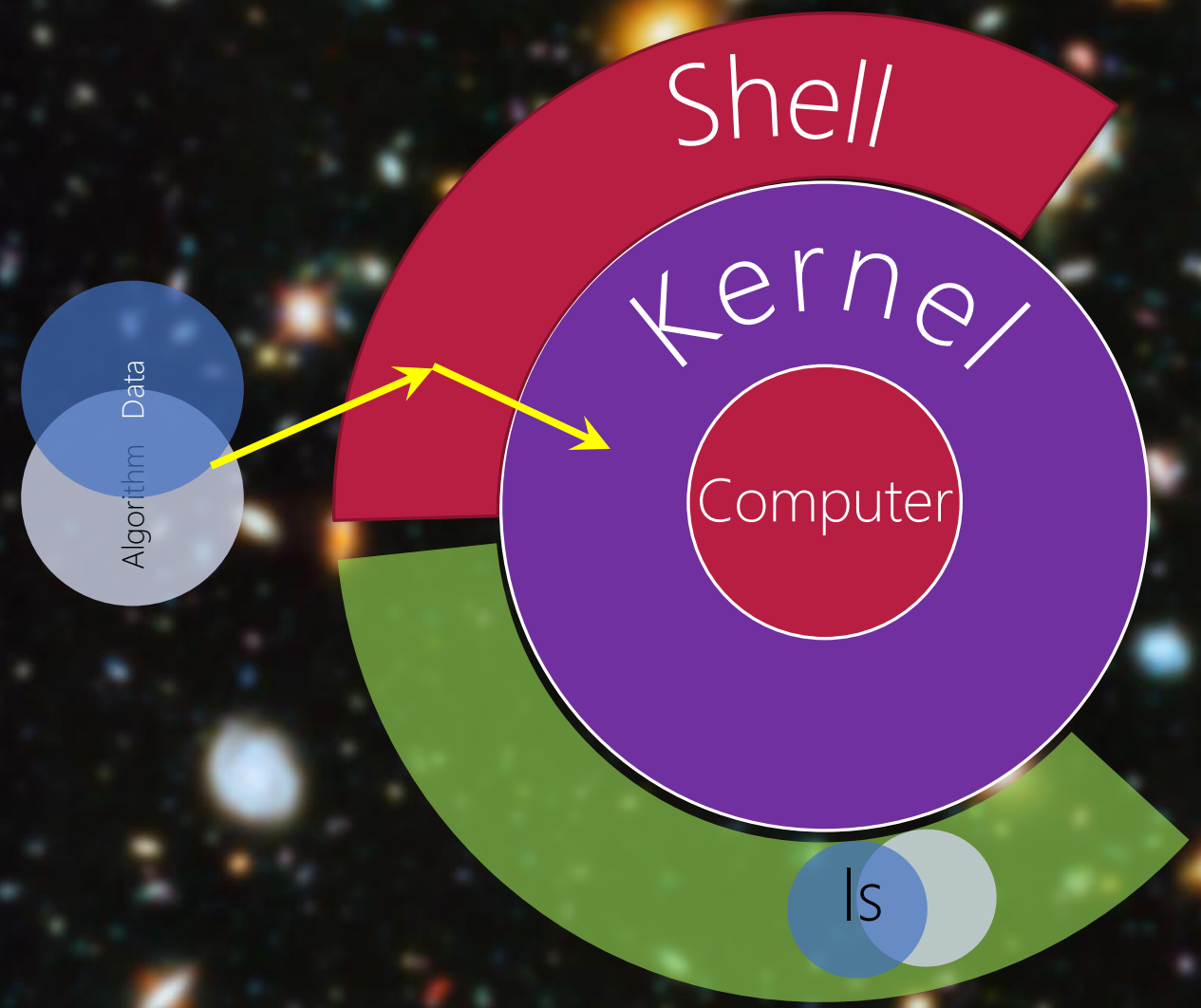
Processor


Shell
Kernel
Computer
Algorithm
Data
Is
Is


Computer
Memory
Kernel
Shell
Process1: Program + Data
Is
Bus
Processor



# DYNAMIC LINK




# Computer

Memory

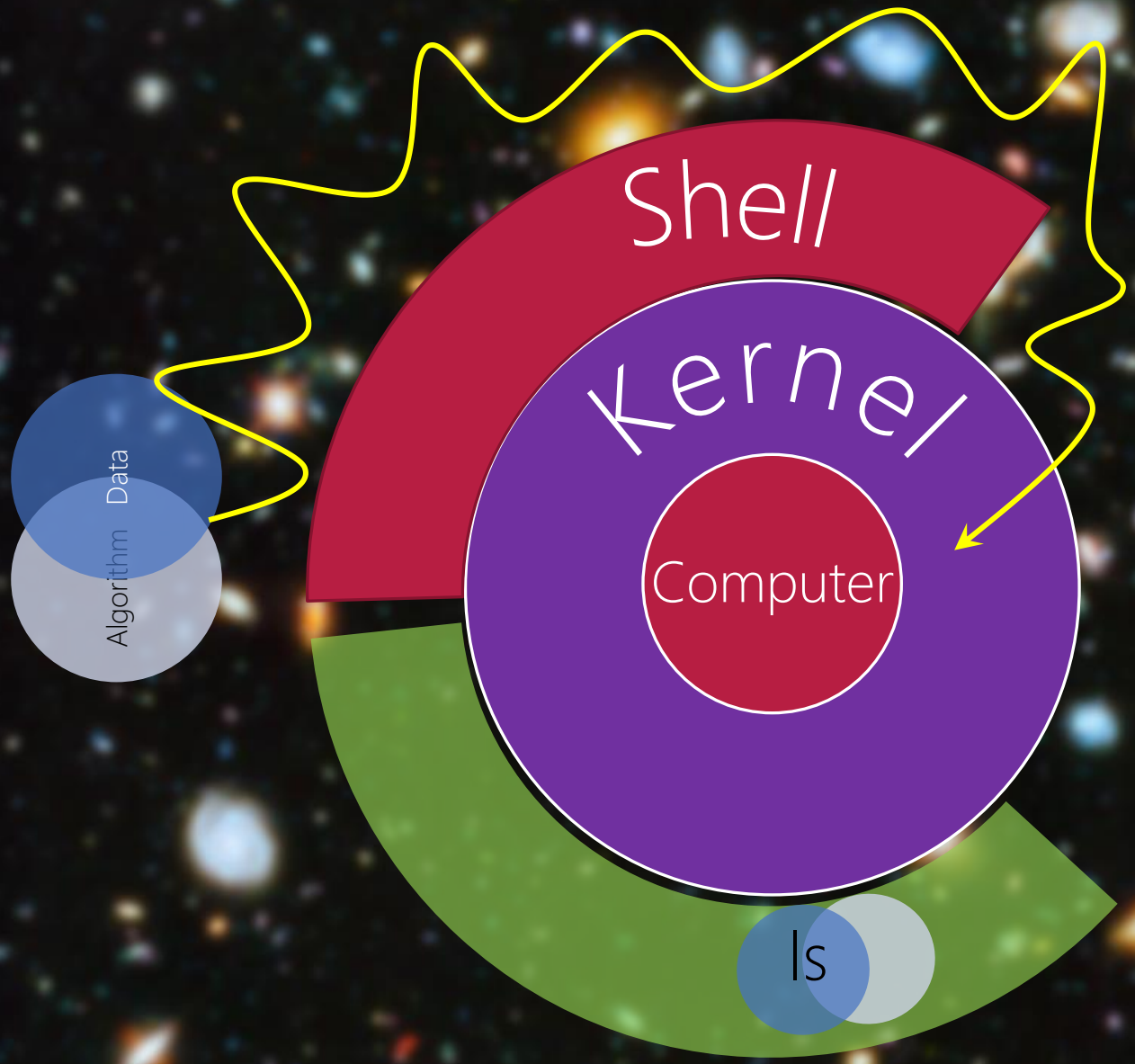
Kernel

Shell

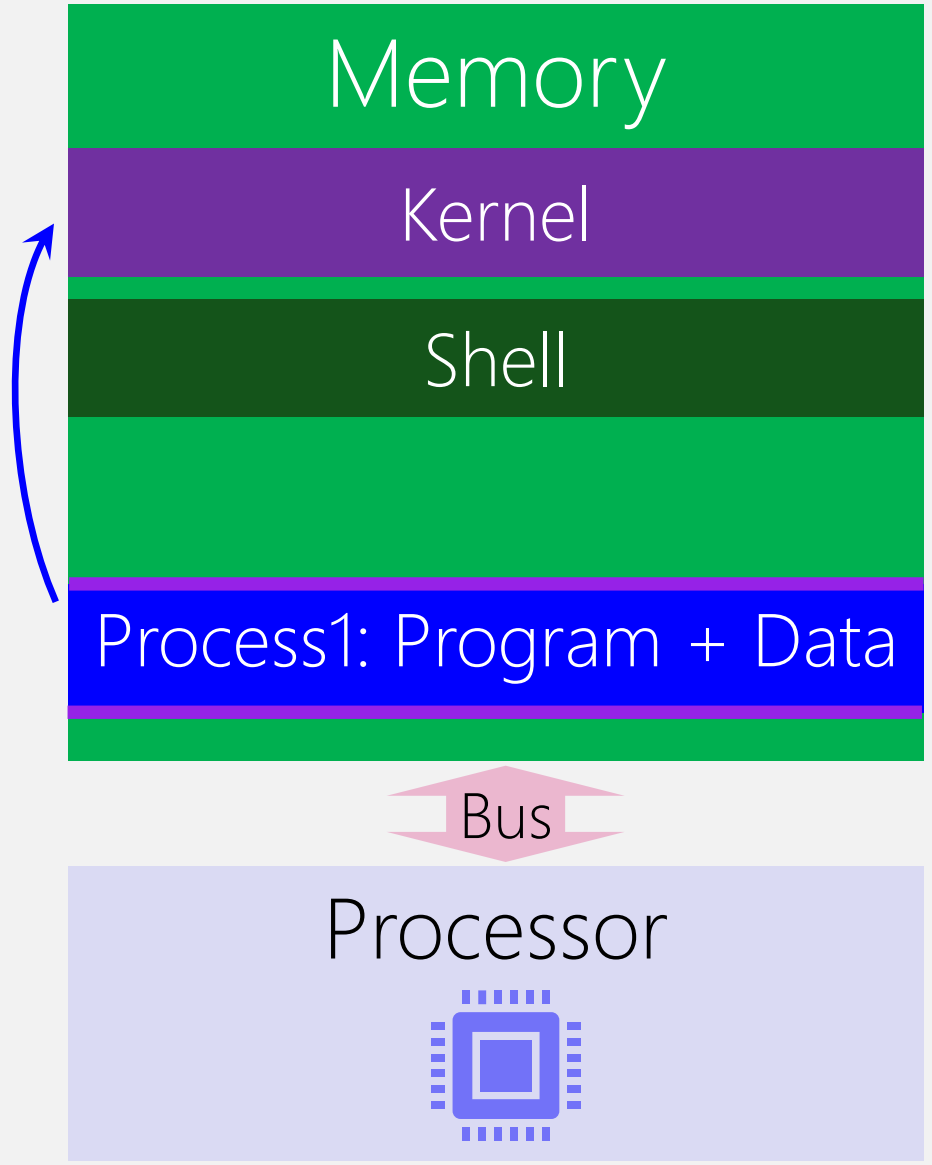
Process1: Program + Data

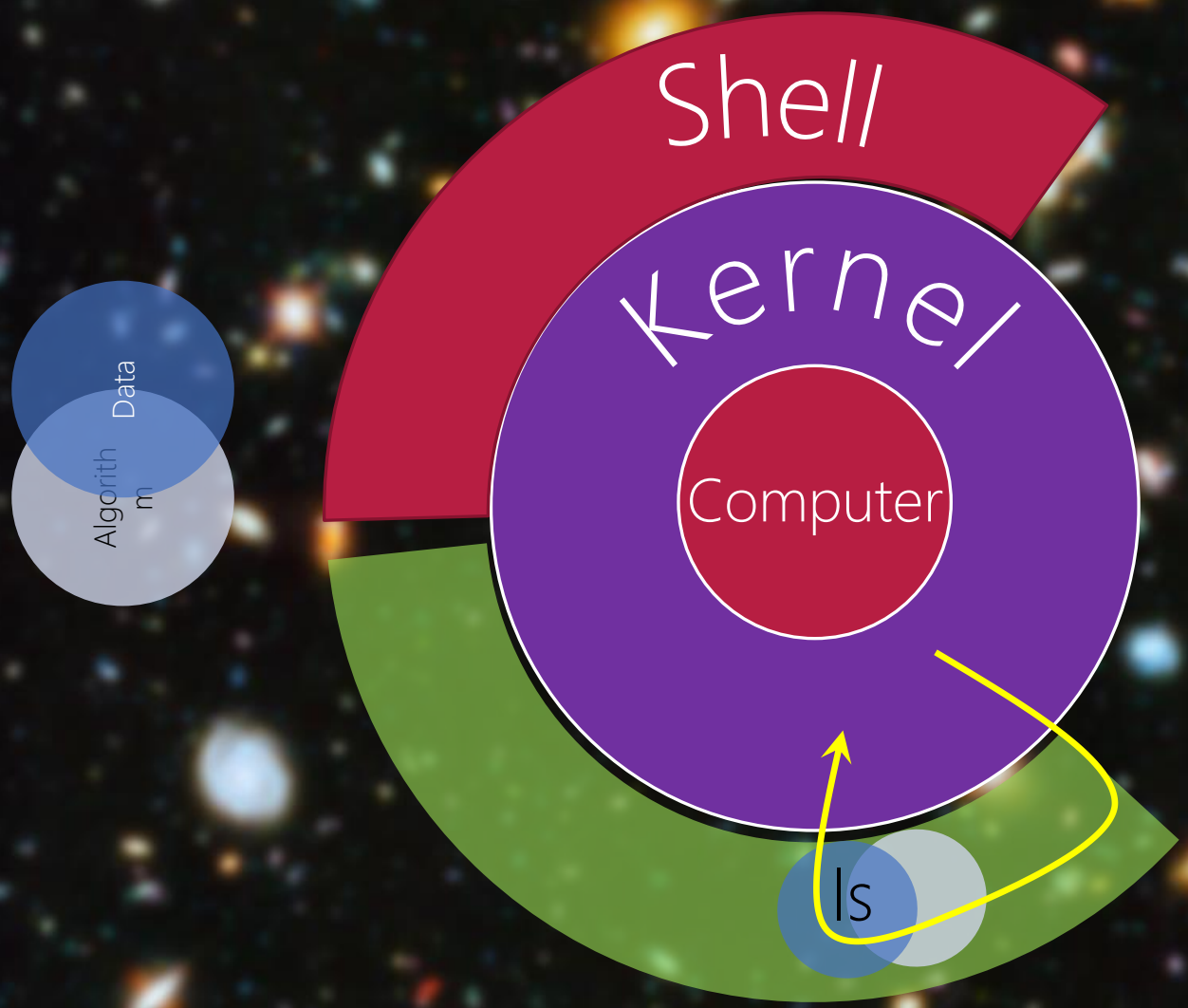
Bus

Processor


Shell
Kernel
Computer
Algorithm
Data
ls

# Computer


Memory
Kernel
Shell
Process1: Program + Data
Bus
Processor


Shell
Kernel
Computer
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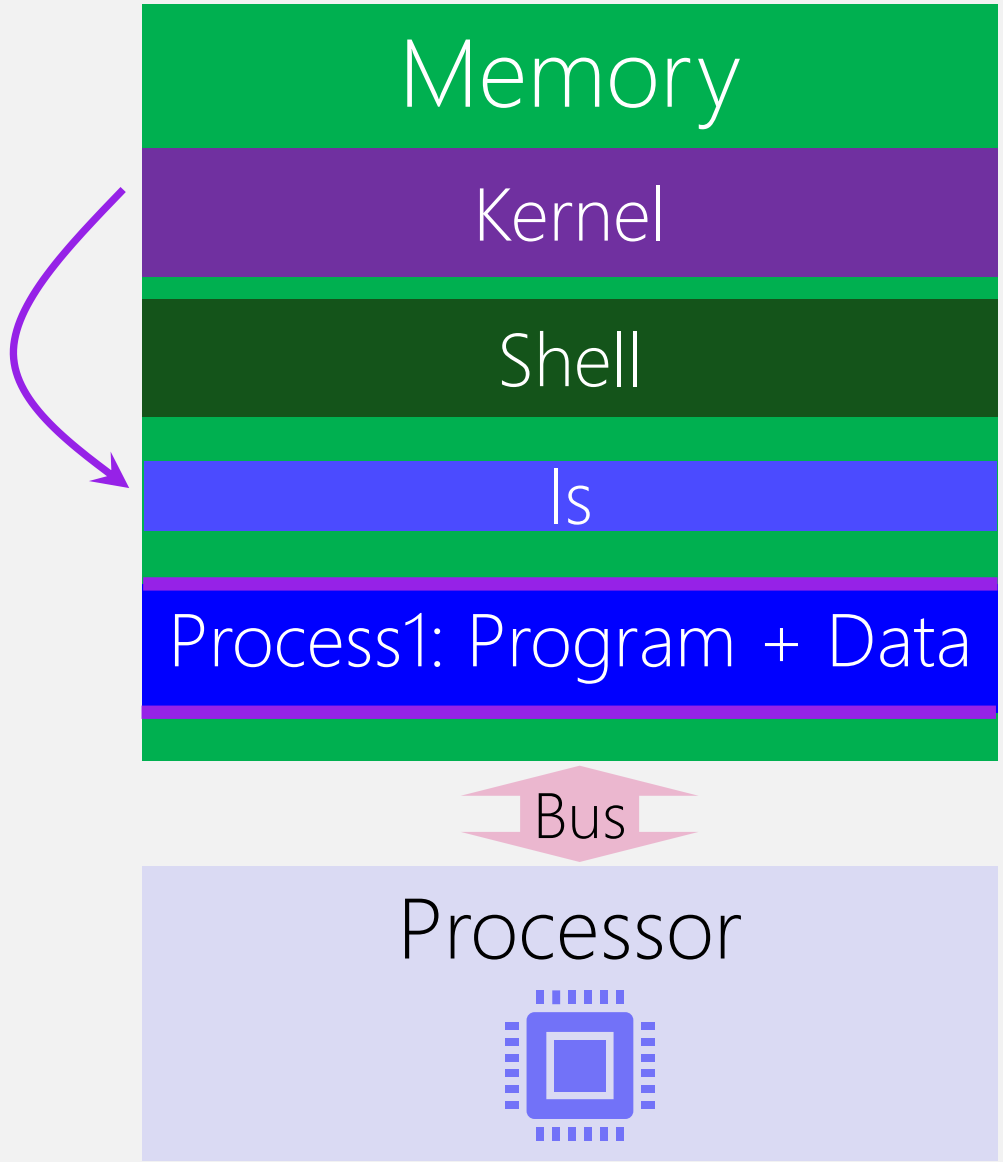
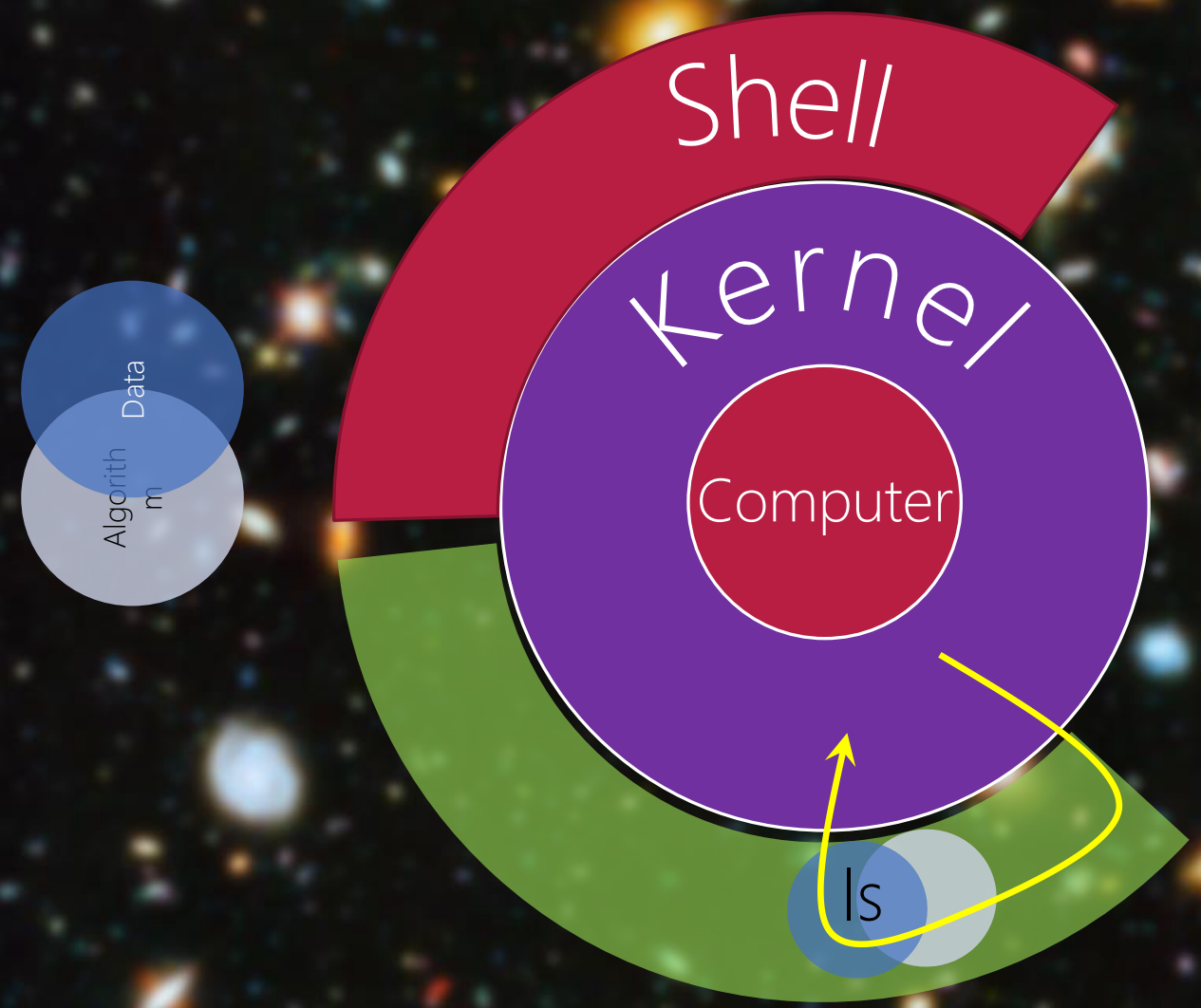
# Computer


Memory
Kernel
Shell
Is
Process1: Program + Data
Bus
Processor




# Computer

Memory

Kernel

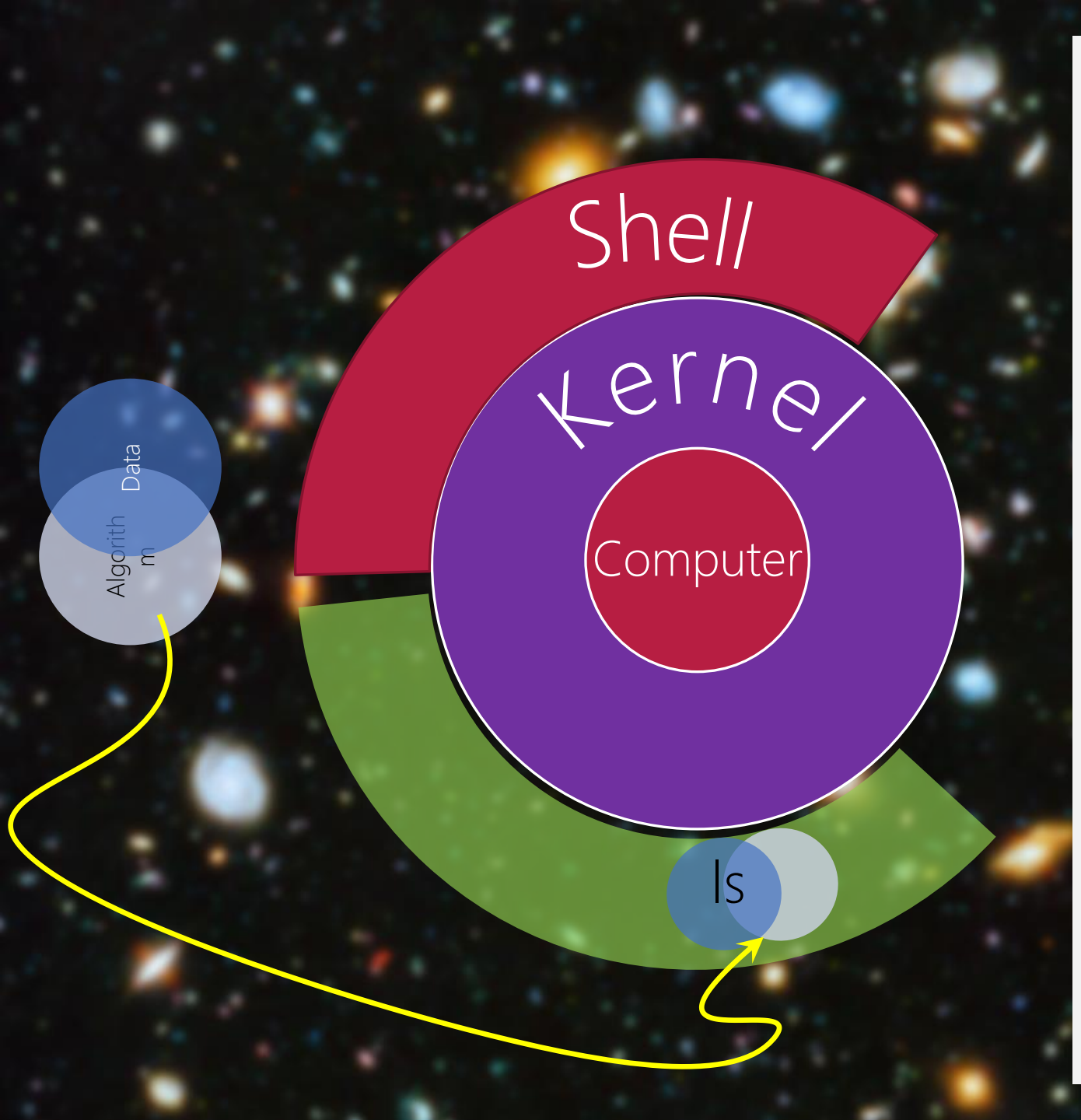
Shell

ls

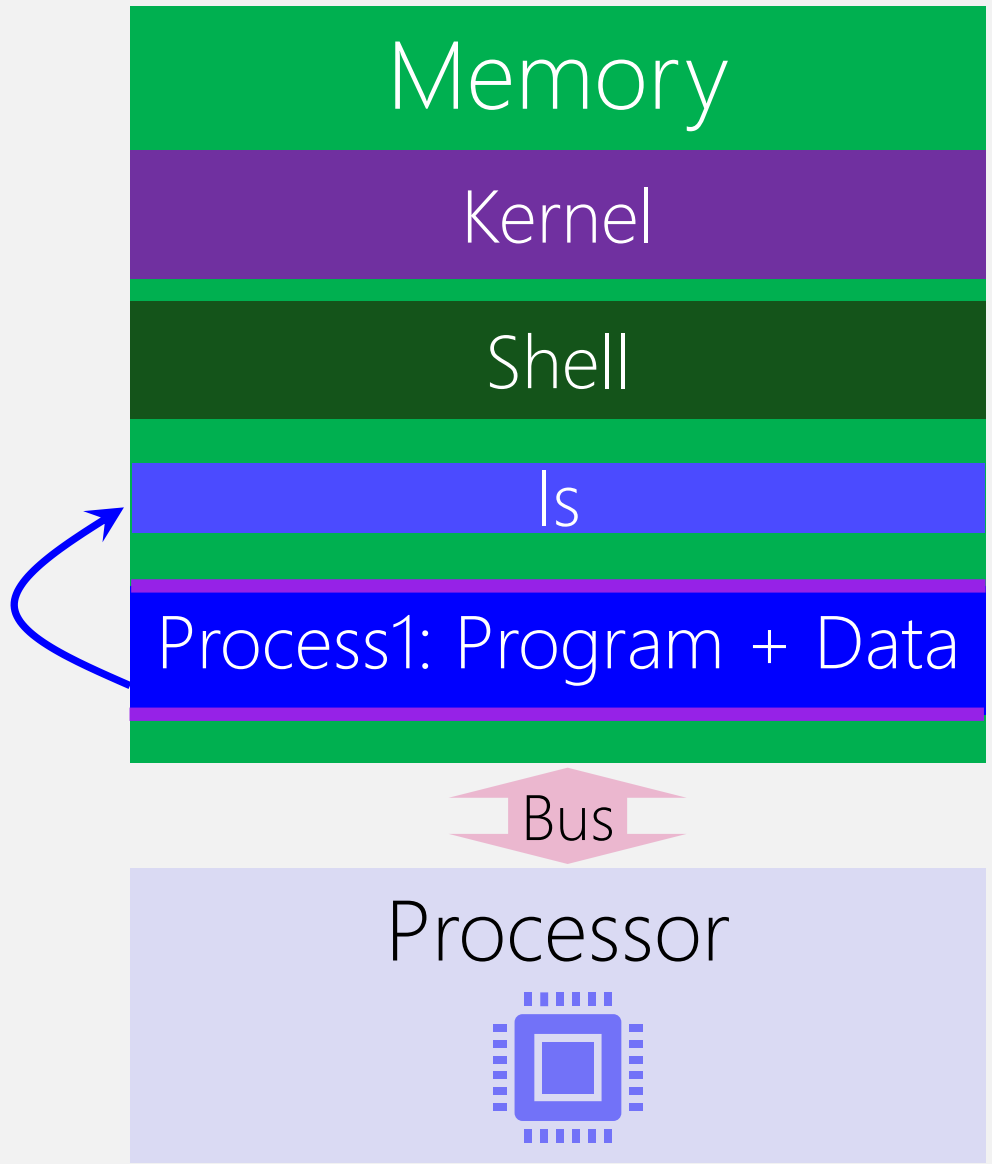
Process1: Program + Data

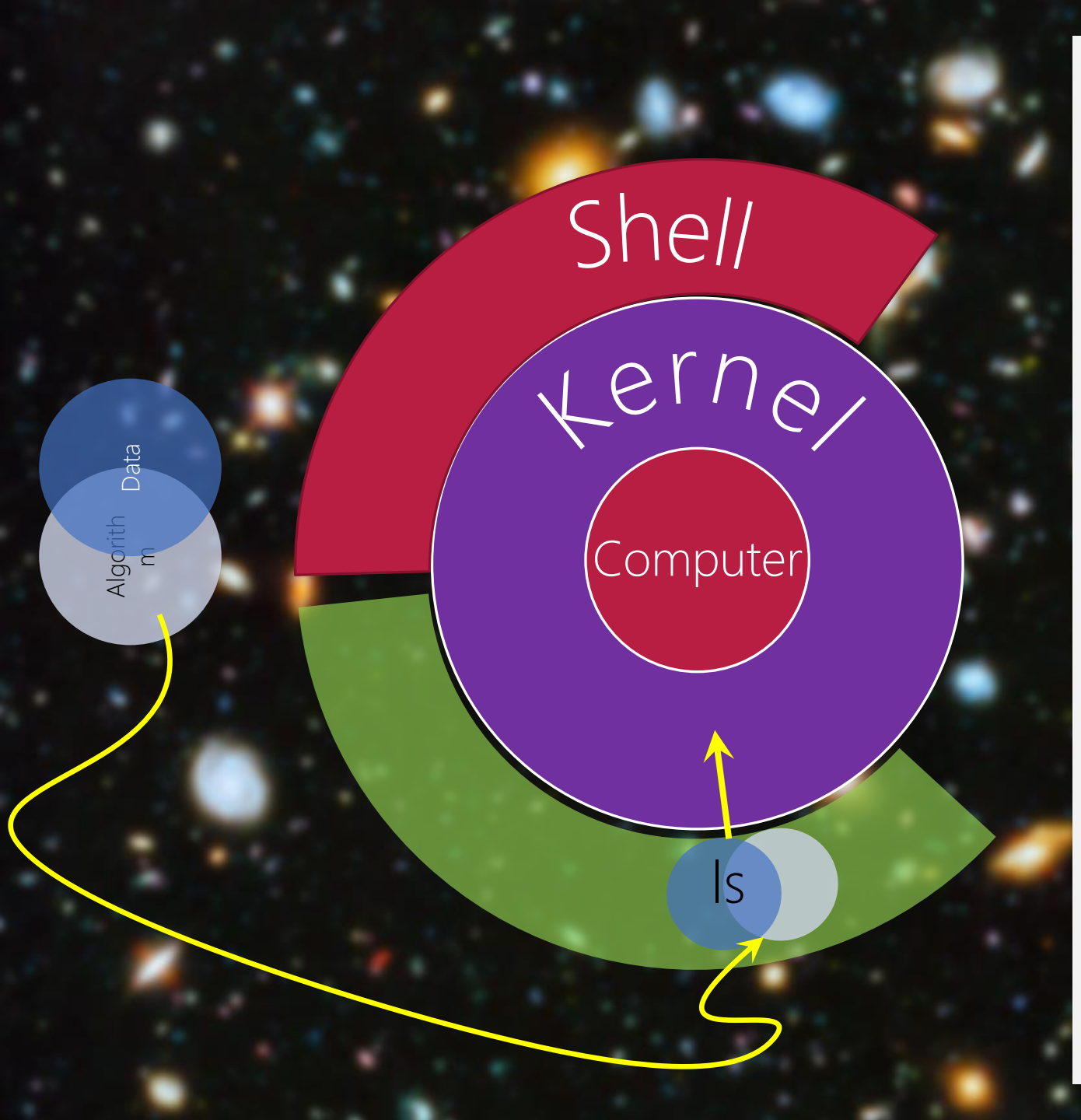
Bus

Processor


Shell
Kernel
Computer
Data
Algorithm
ls

# Computer


Memory
Kernel
Shell
ls
Process1: Program + Data
Bus
Processor


Shell
Kernel
Computer
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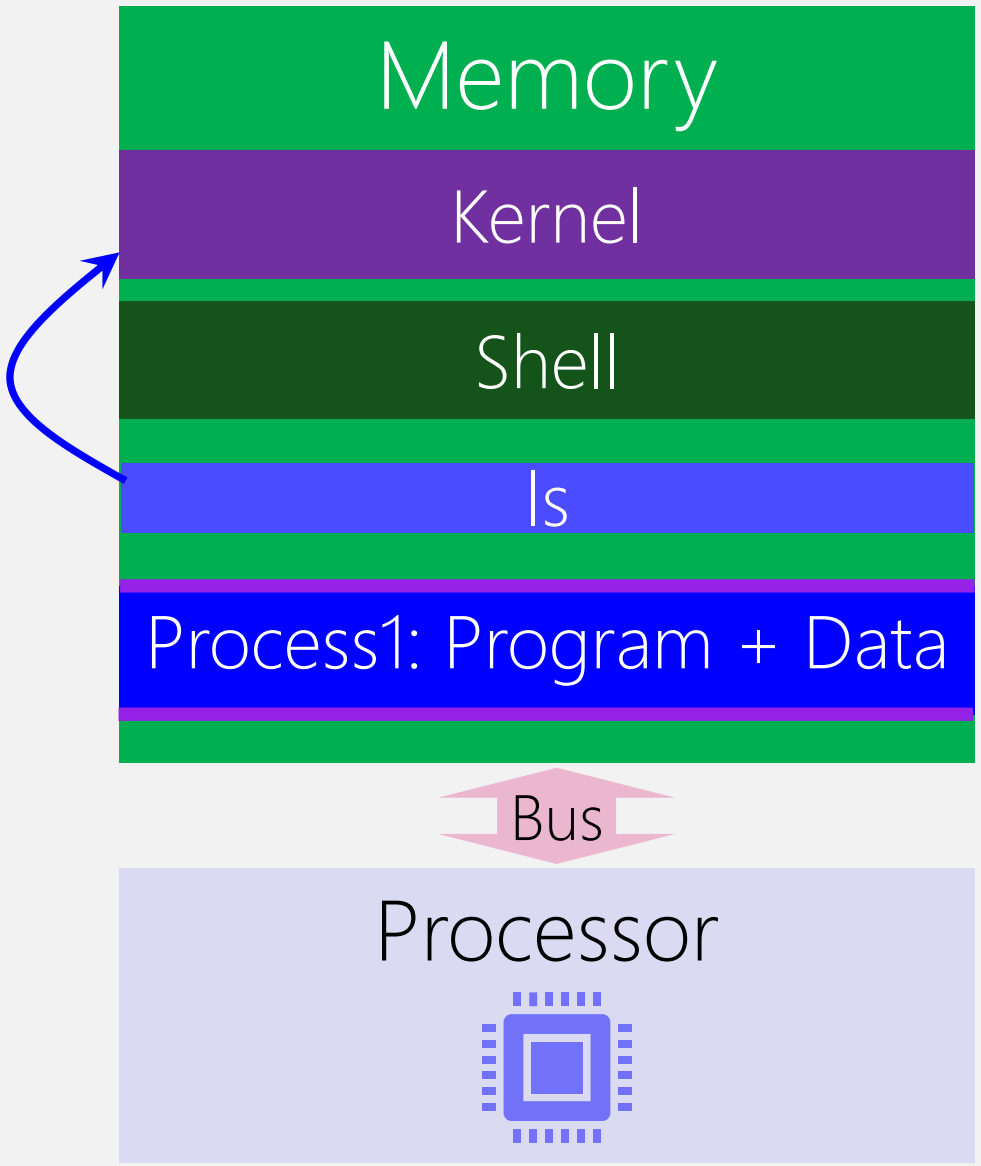
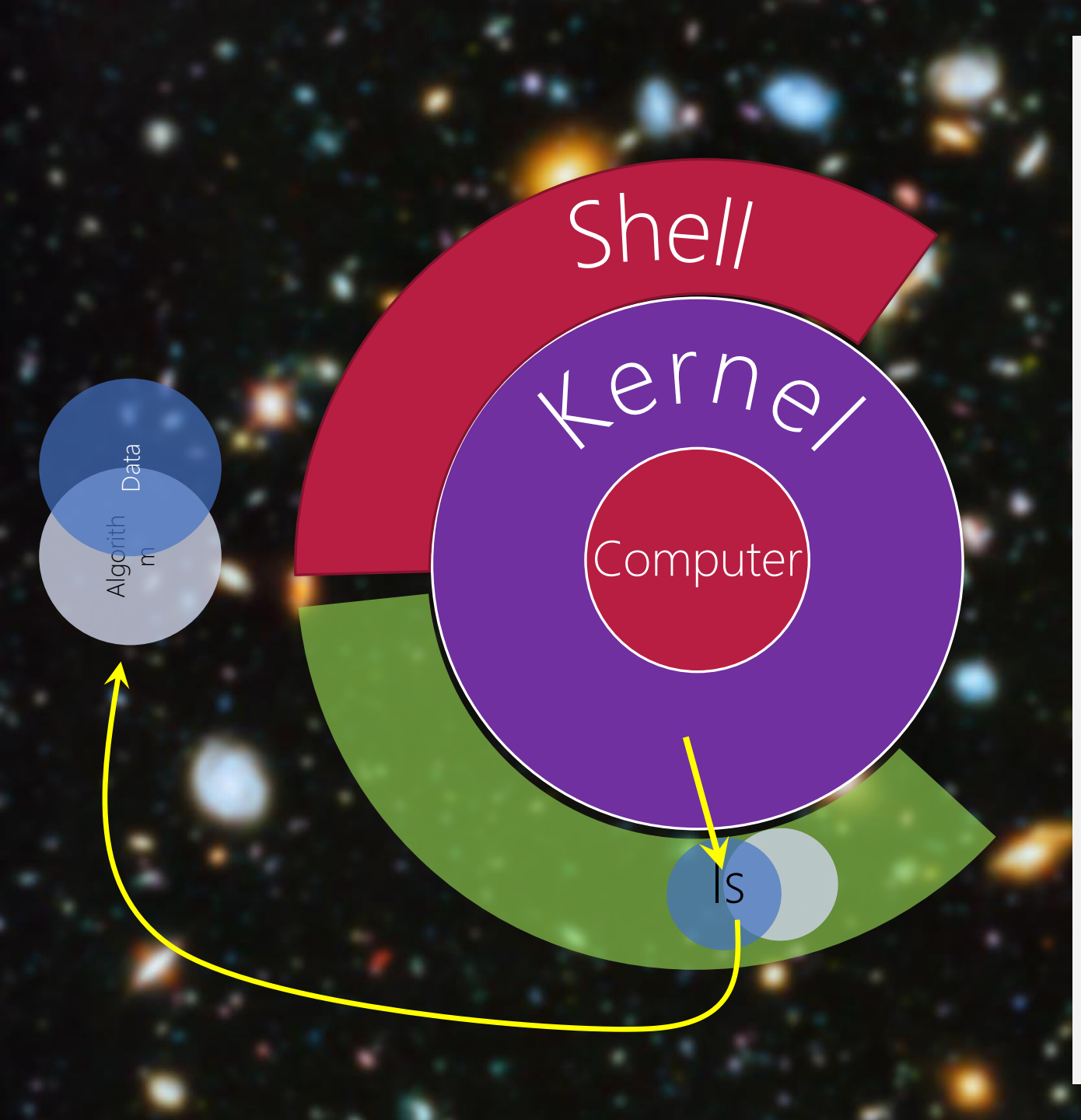
ls

# Computer


Memory
Kernel
Shell
ls
Process1: Program + Data
Bus
Processor


Shell
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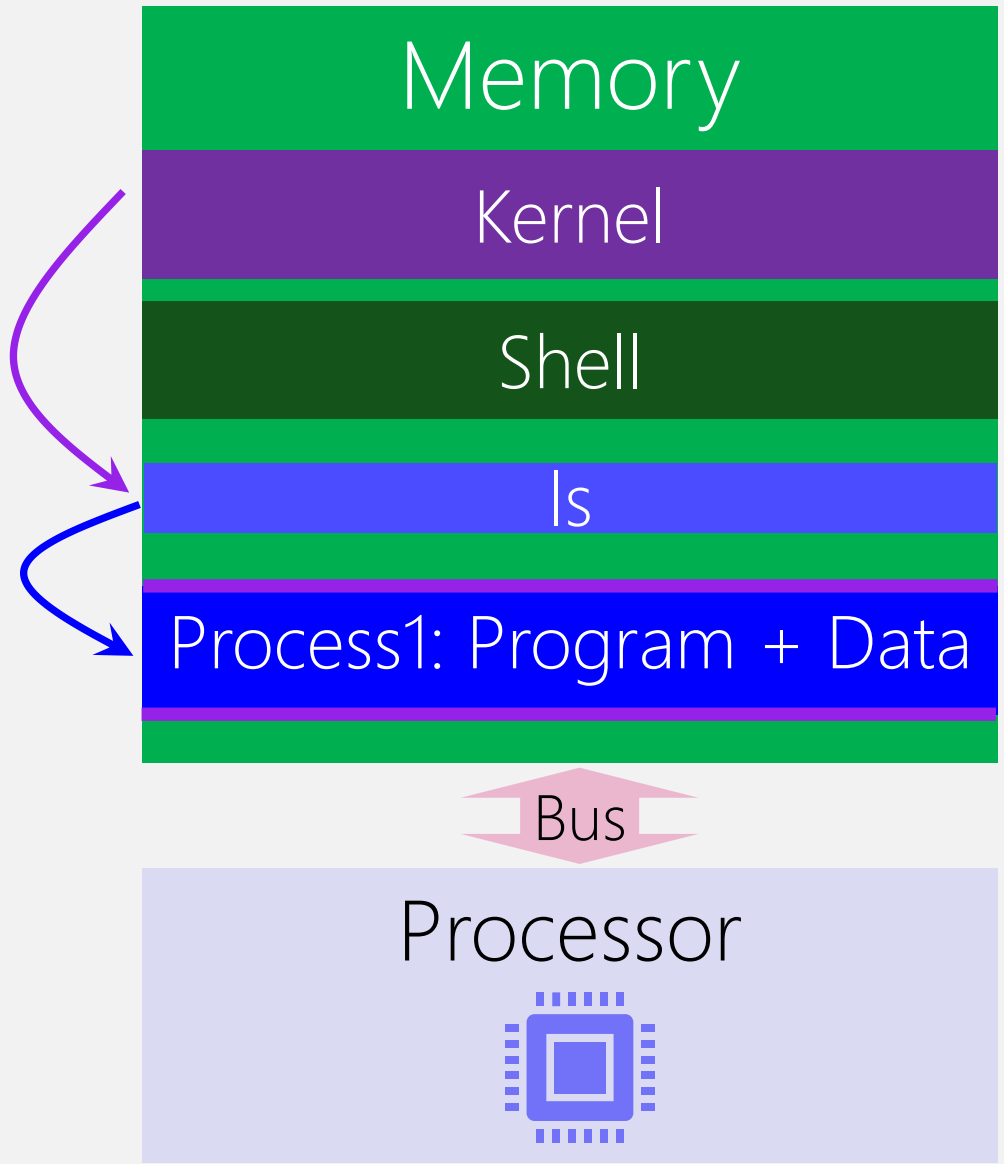
# Computer


Memory
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Process1: Program + Data
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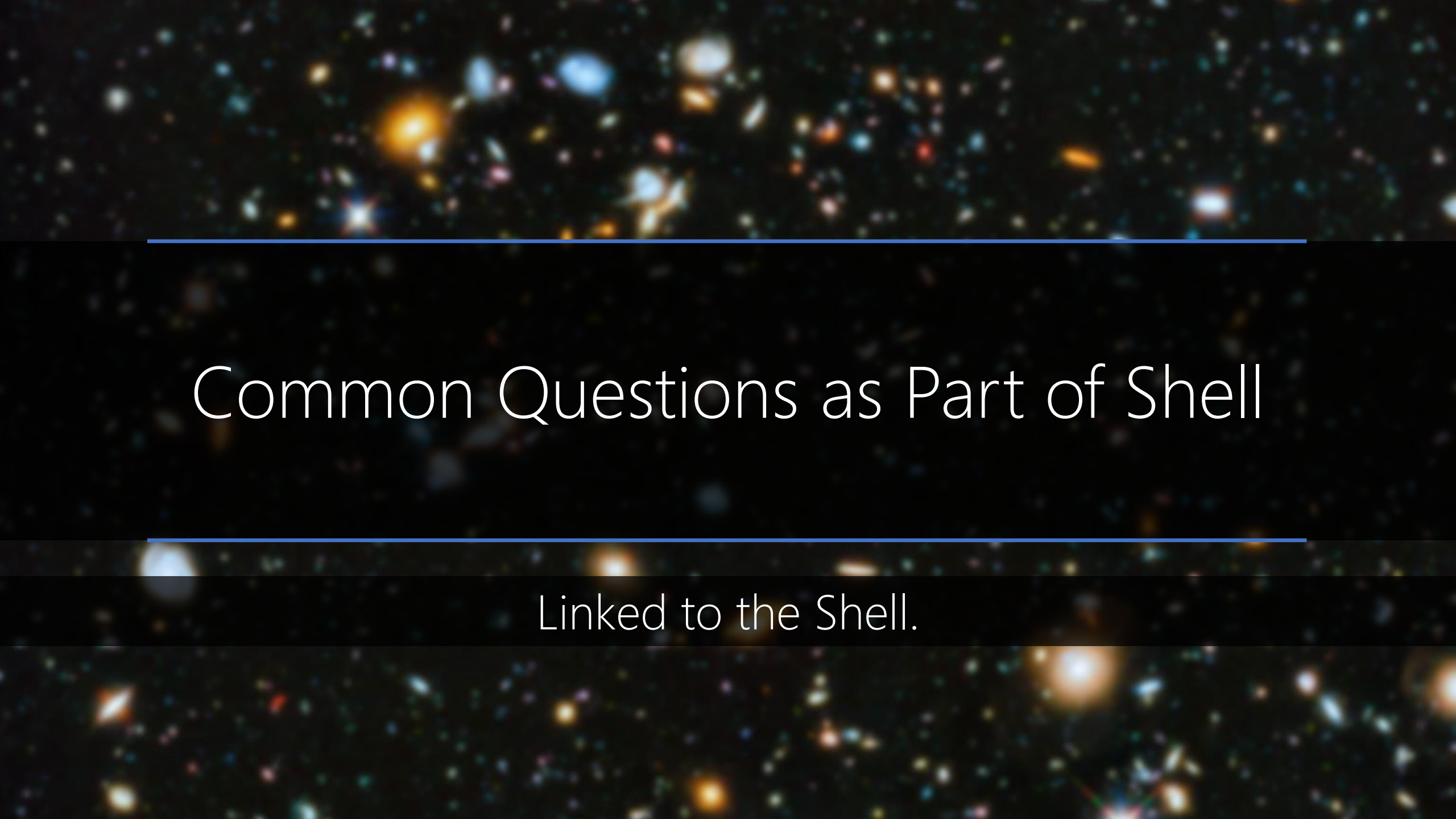
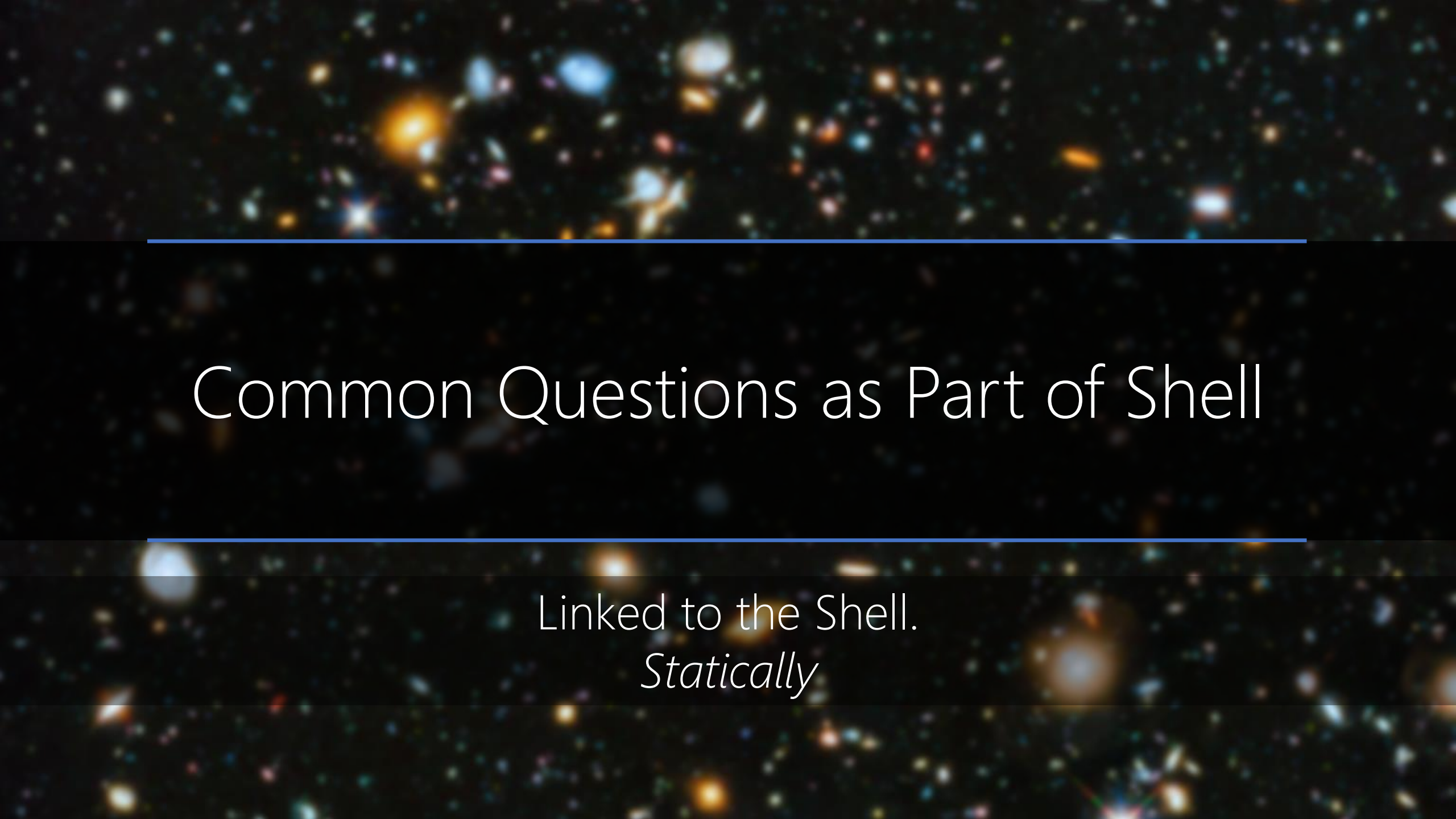


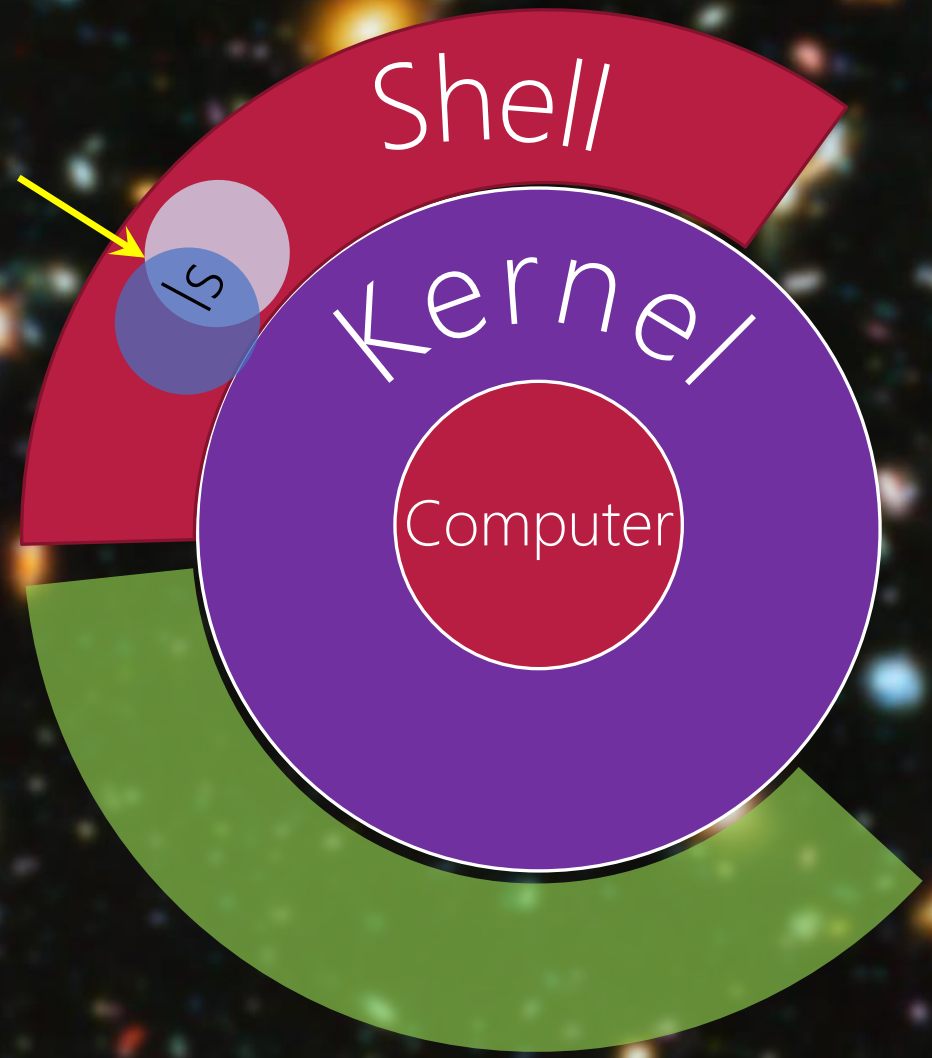
# Common Questions as Part of Shell

Linked to the Shell.



# Common Questions as Part of Shell

Linked to the Shell.
*Statically*




# Computer

Memory

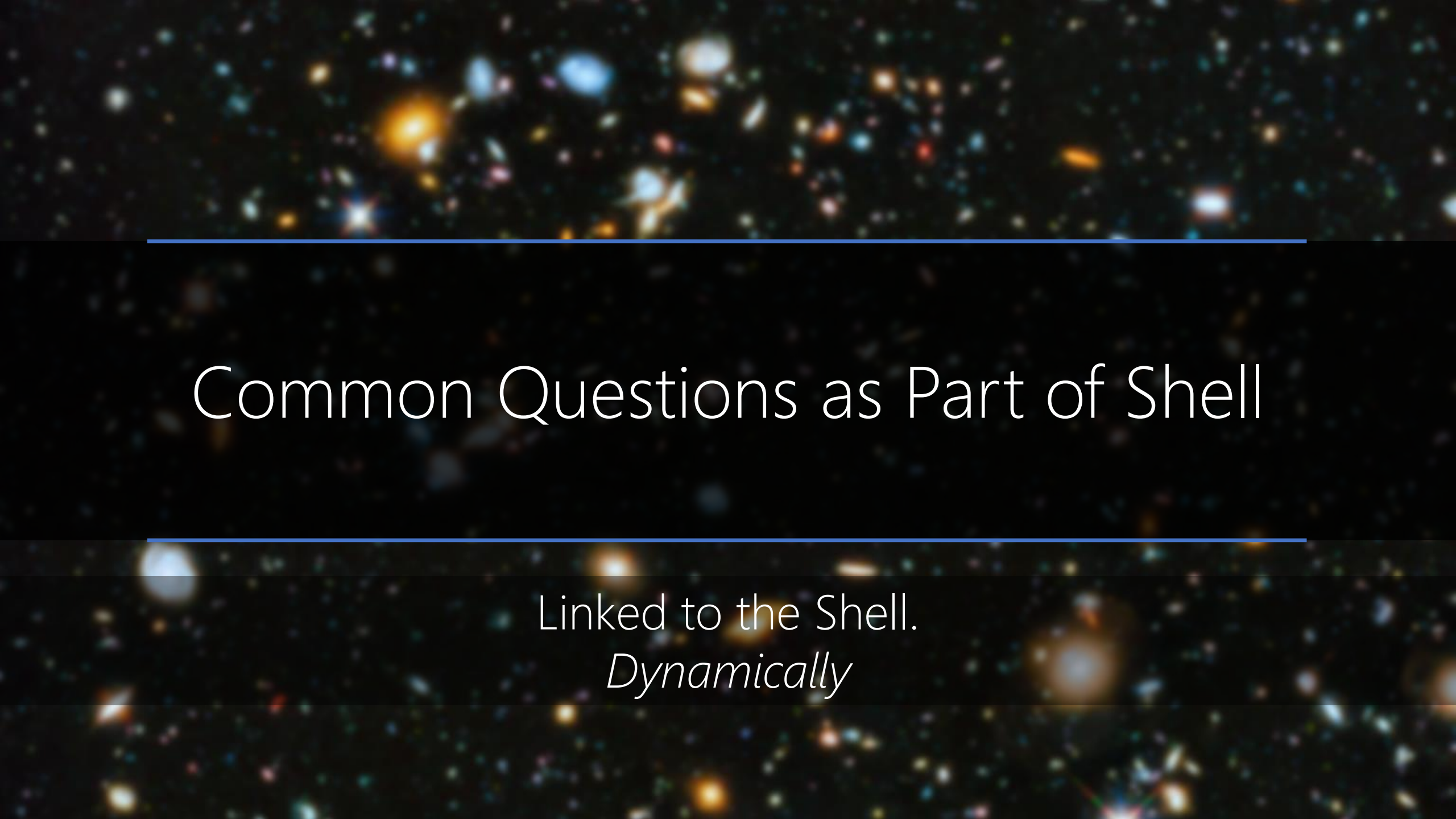
Kernel

Shell

ls

Bus

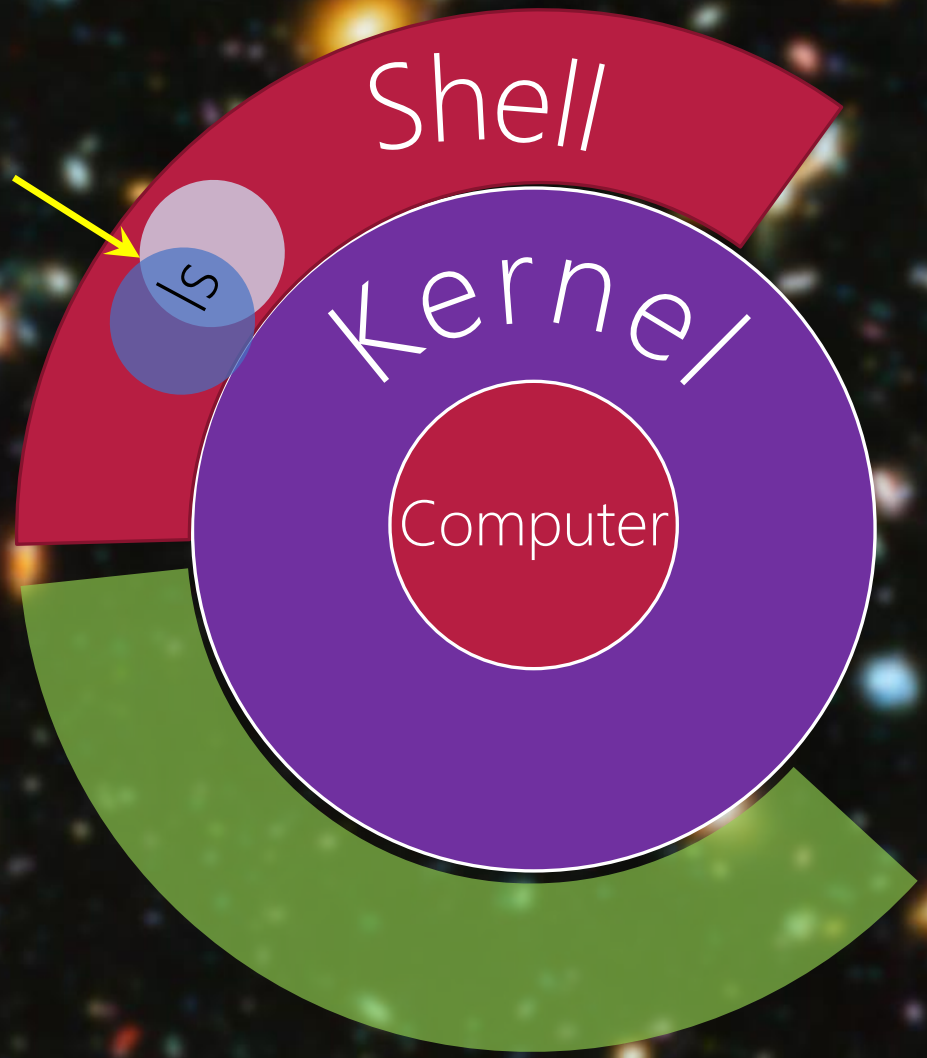
Processor



# Common Questions as Part of Shell

Linked to the Shell.

*Dynamically*




# Computer

Memory

Kernel

Shell

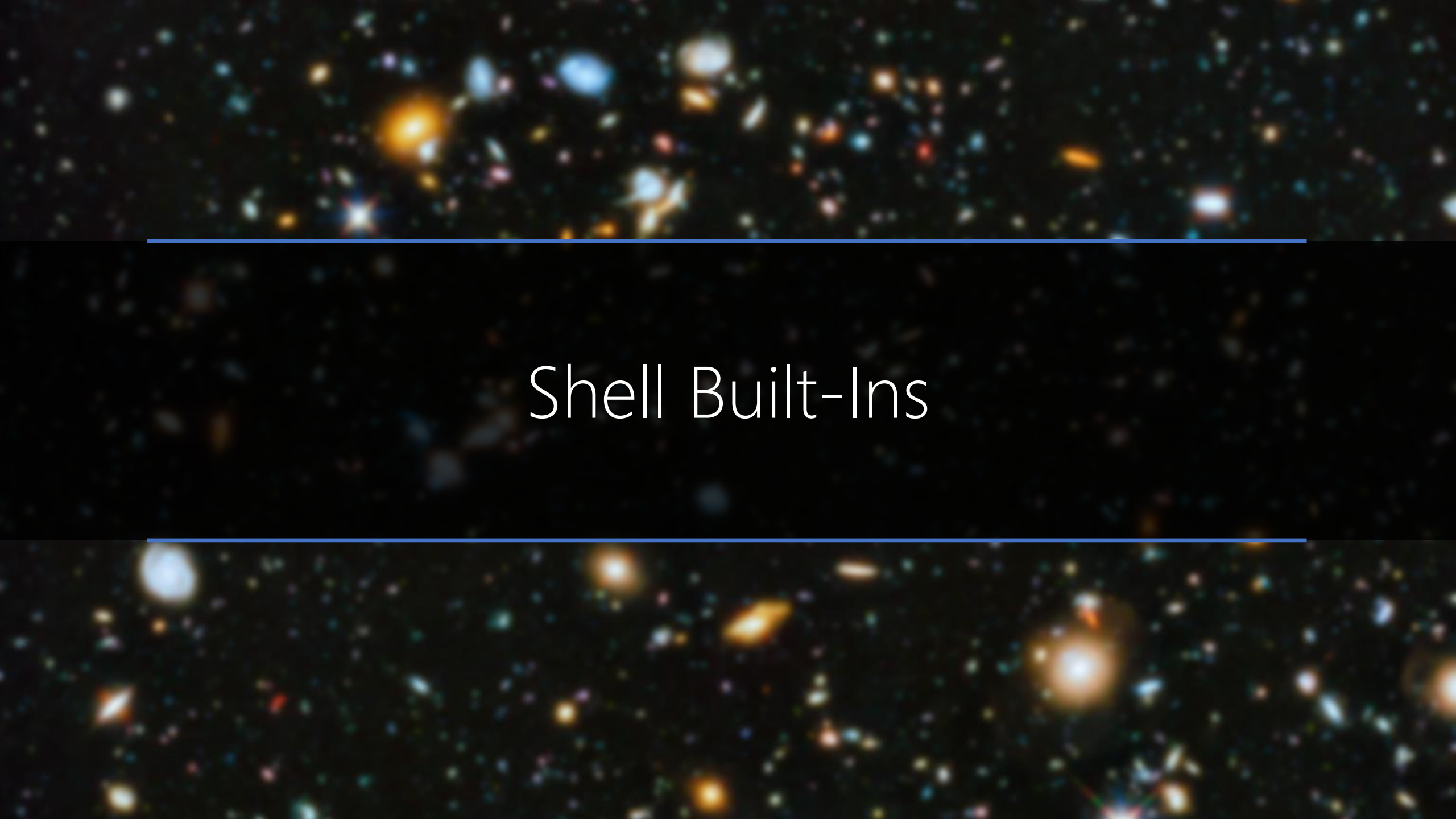
ls

Bus

Processor

```
hfani@alpha:~$ ls
```

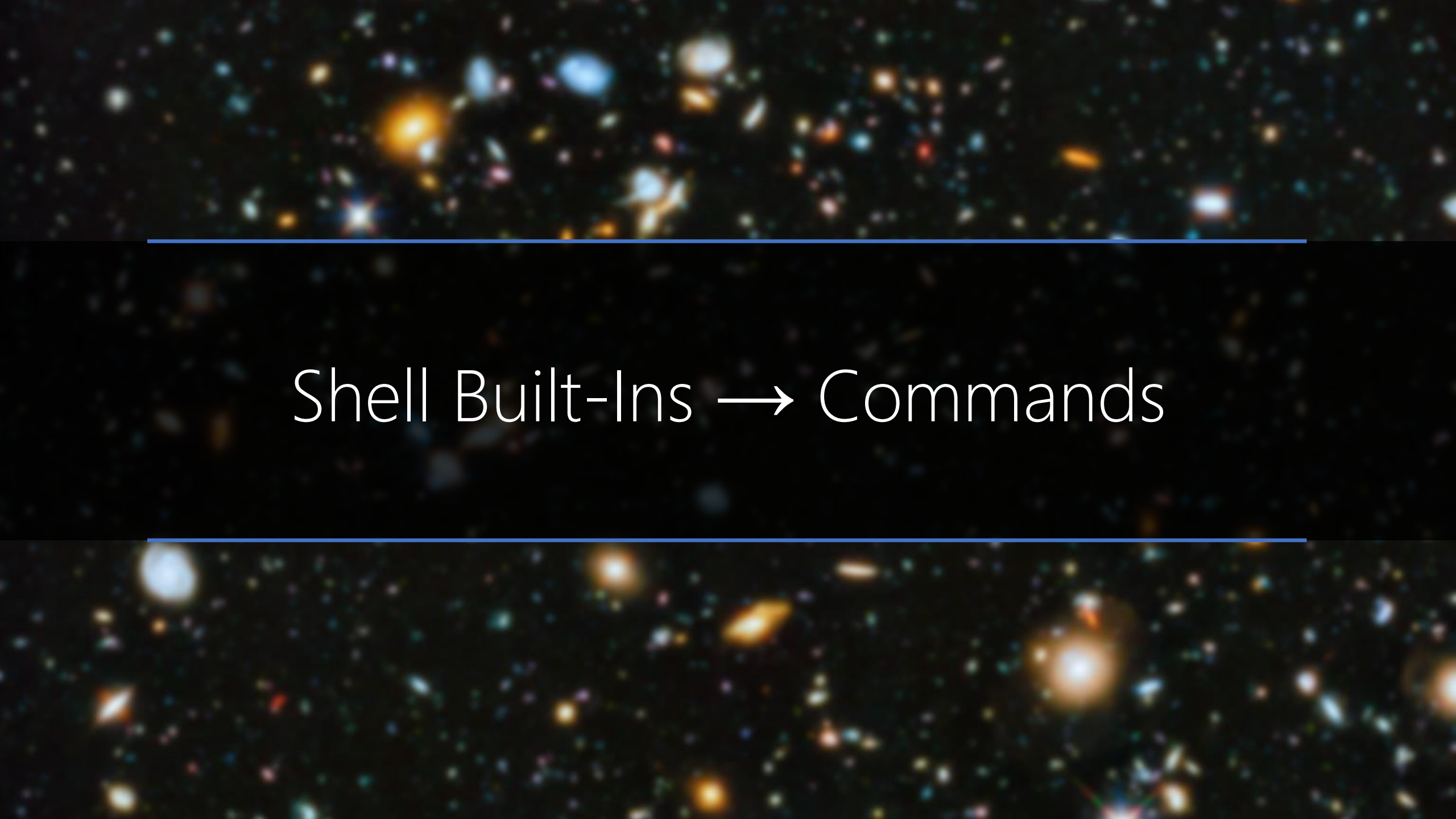
```
hfani@bravo:~$ ls
build_lab03.sh  Downloads          hello.c       increment.o  main    main.s       Pictures   test.sh
Desktop         eclipse-workspace  hellocat.txt  increment.s  main.c  Music        Public     Videos
Documents       hello              increment.c   ls.c         main.o  myscript.sh  Templates
hfani@bravo:~$ ls /
amd64_packages  dev     home           lib    libx32      media        opt   run   srv  usr      vmlinuz.old
bin             etc     initrd.img     lib32  local       mnt          proc  sbin  sys  var
boot            global  initrd.img.old  lib64  lost+found  nonexistent  root  seed  tmp  vmlinuz
hfani@bravo:~$ ls /home
60214          chen1fl        gill142          kobtic          nawazn          rebkowes          swayzed
60280          chen1k2        gill149          kogelt          nazal           reelyt            syalo
60311          chen2d         gill14l          kohli111        ndiayep         reen              syed11r
aanku          chen74         gill15q          kohli8          ndibanj         reid137           syed126
abbas51        chen9i         gill22           kojicl          nealj           reingolv          syed129
abbasit        cheng134       gill59           kollarm         necioo          rempilljj         syeda1
abbiedyck      cheng143       gill95           kollere         needsm          renau11s          syedai
abdall51       cherkup        gilliamd         komarin         neisari         renau121          syedmuz1
abdelba        cherryn        giorlan1         kondepu         nesarajm        renaud2p          sylvest7
abduelm1       chertova       giwaf            kongw           newto115        renaud2y          symons1
abdull1u       chhabrat       gliu             kooplic         ng122           renaud91          szeen
abdull1v       chhabri        gloria           kopco111        ng12a           repmannc          szuckia
abdulghh       chiangb        glovern          kopliku         ngaiv           reynold5          szucs1
abdulnan       chiarcod       godavars         koratk          ngo113          rezaei            tabbeno
abesi          chibuzo        godfather        korkis1         nguy            rezaeia           tadros2
abeygunj       chikhalt       godhania         koshiyap        nguye115        rezaz             tahan
abidaf         chikkamb       godin            koshtit         nguye141        rgras             tahay
abouali        chittle5       godlewso         koshula         nguye145        riaz9             taher5
abouass        chittleb       gomezi           kotha111        nguye14b        ricci6            taifour
abouelg        chohanu        gomezma          kotha113        nguye159        rice118           tailo115
aboughat       chokshia       gongj            kothapa1        nguyen1v        rice11c           tainga
aboughm        cholaghc       gongo            kothapap        nguyen2r        richar63          takacha
abouha11       chopdan        goodisoc         kottoort        nguyen43        richard           takamorr
abrah111       chopr11b       goodm111         kouhang         nguyen4e        richard.arsenault takev
```



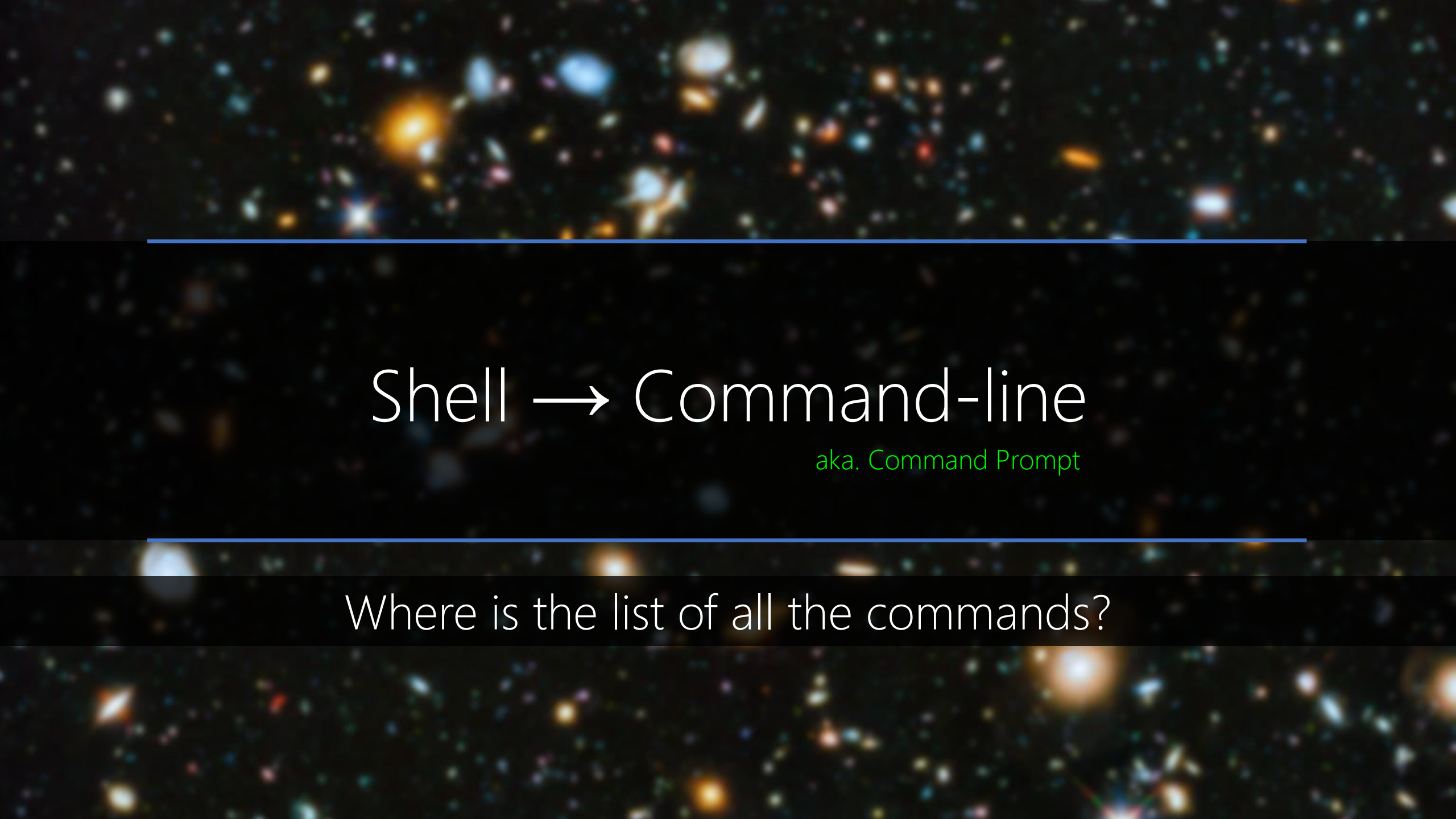
# Shell Built-Ins

# Not Only Questions But Also Commands

Delete this file, please!
Remove this folder and all its content, please!
Make this file hidden, please!
Move this file from location A to B, please!
Copy this file from location A to B, please!
…



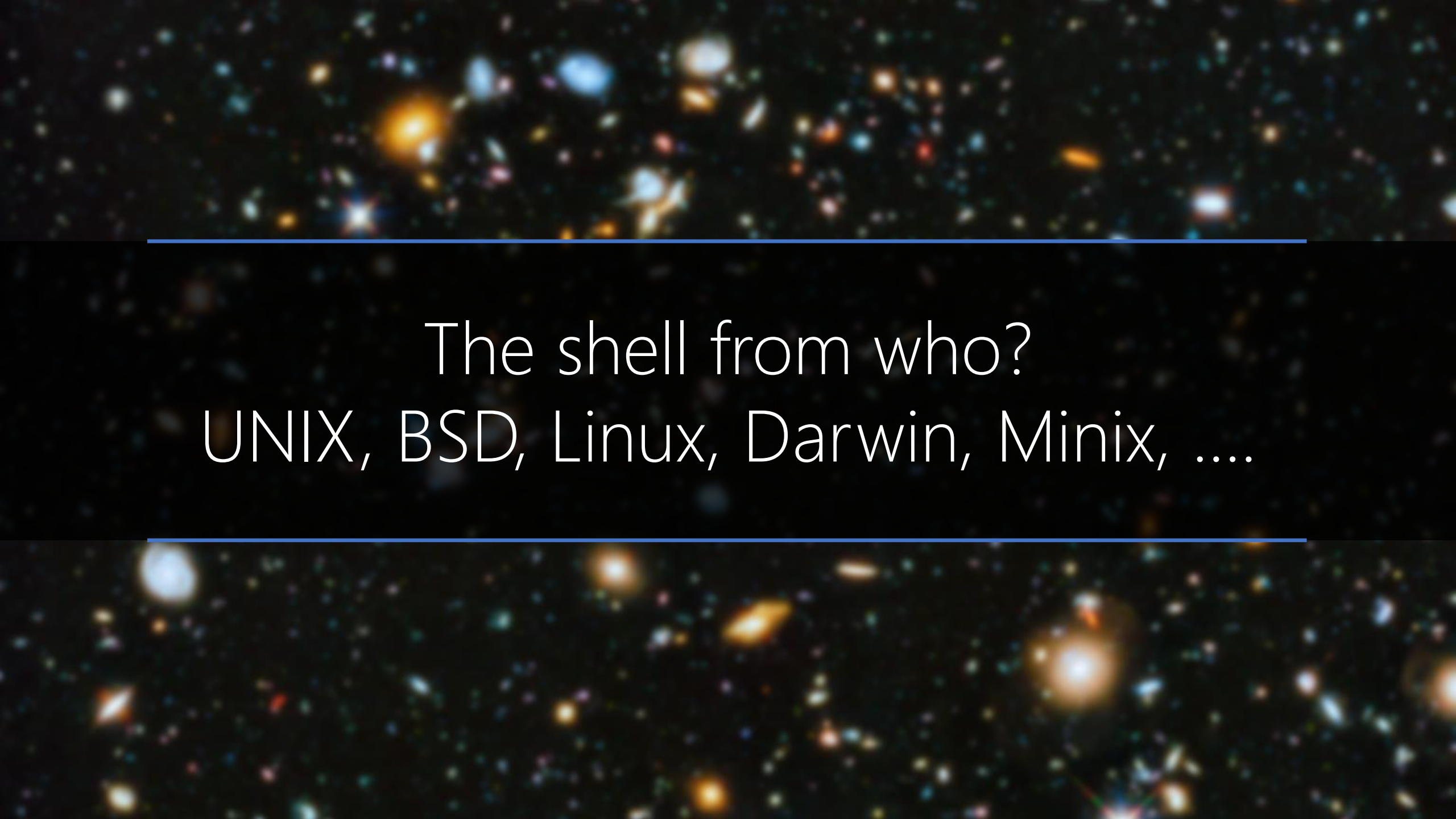
# Shell Built-Ins ⟶ Commands

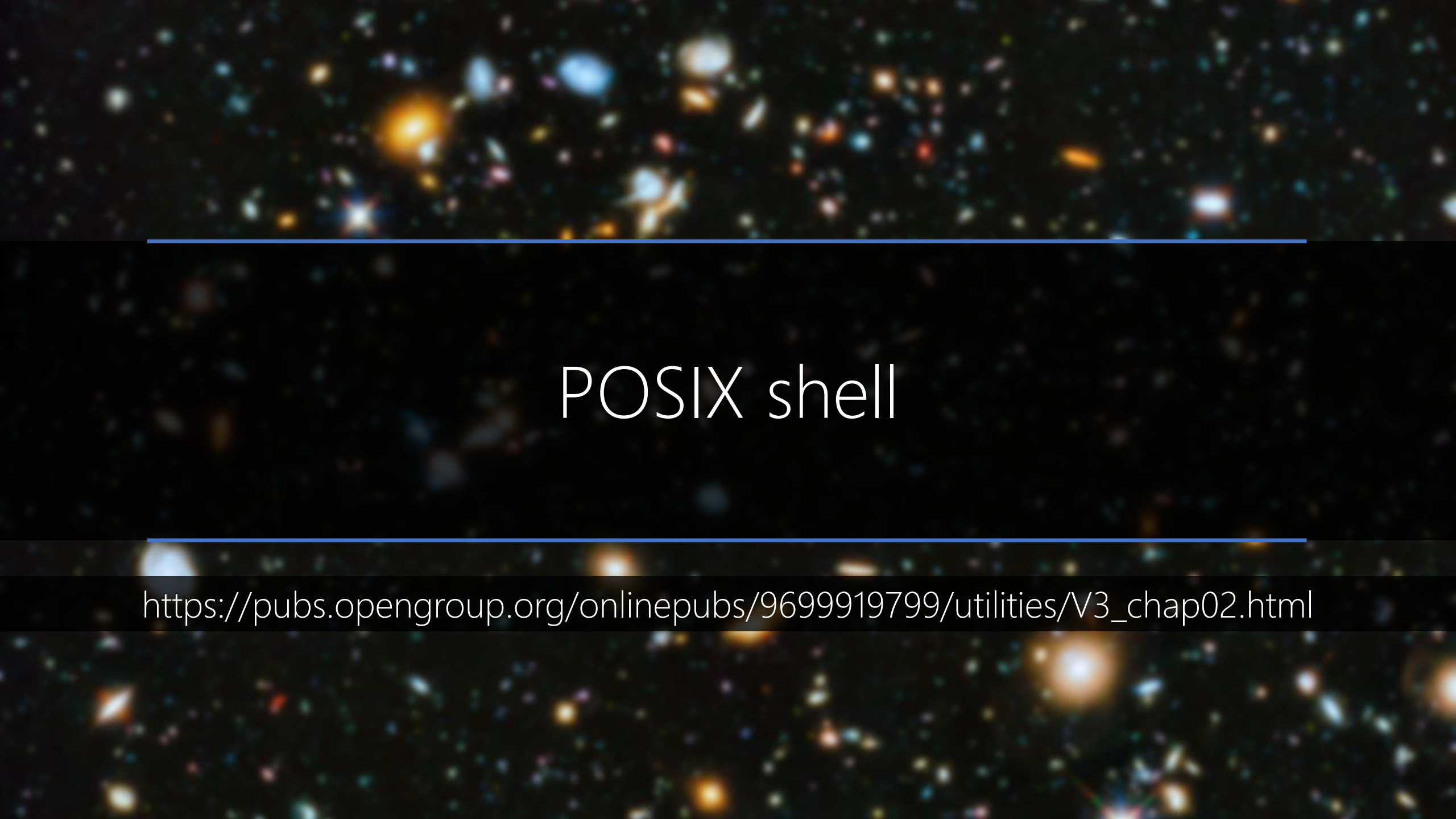


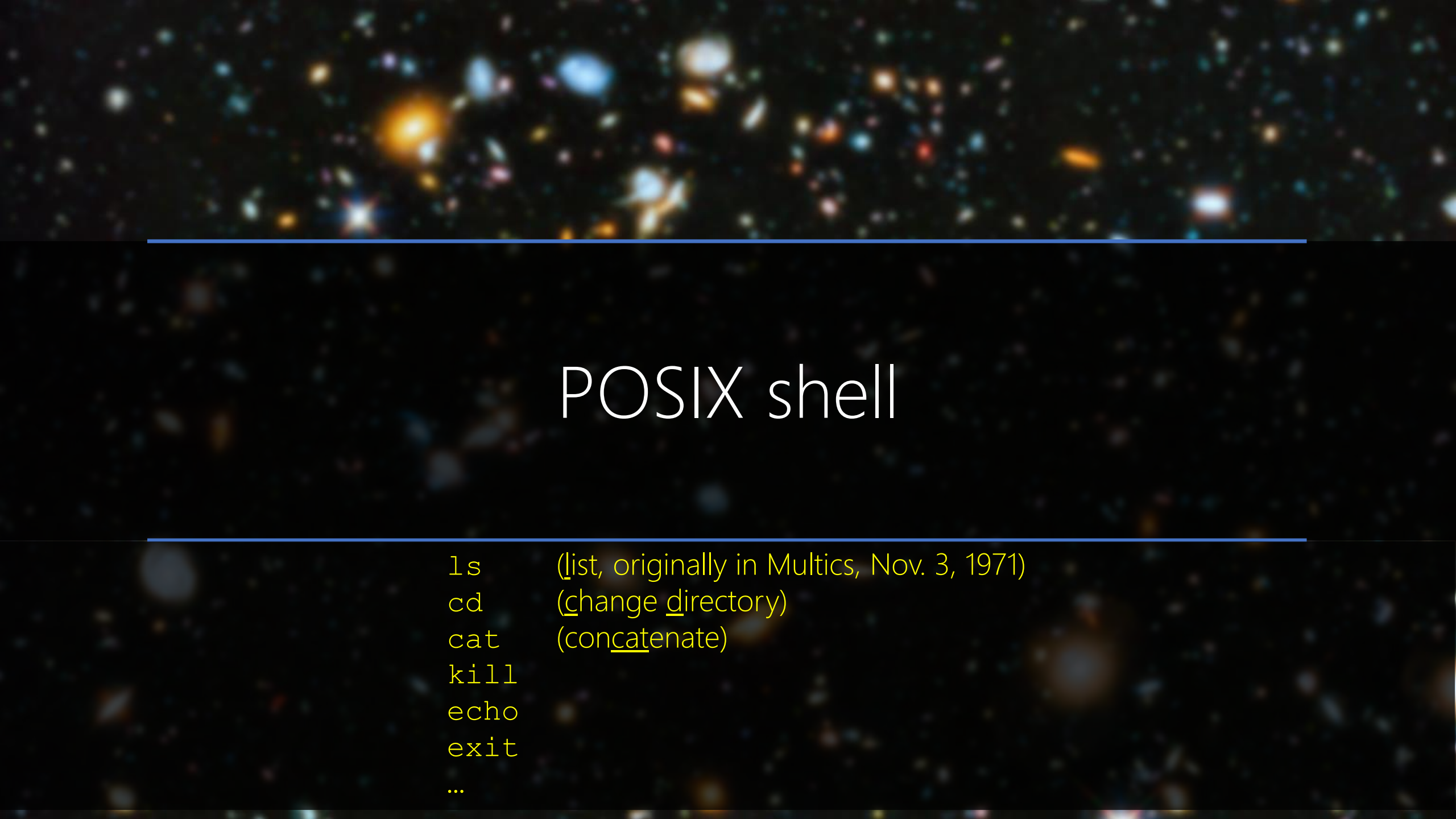
# Shell → Command-line

aka. Command Prompt

Where is the list of all the commands?

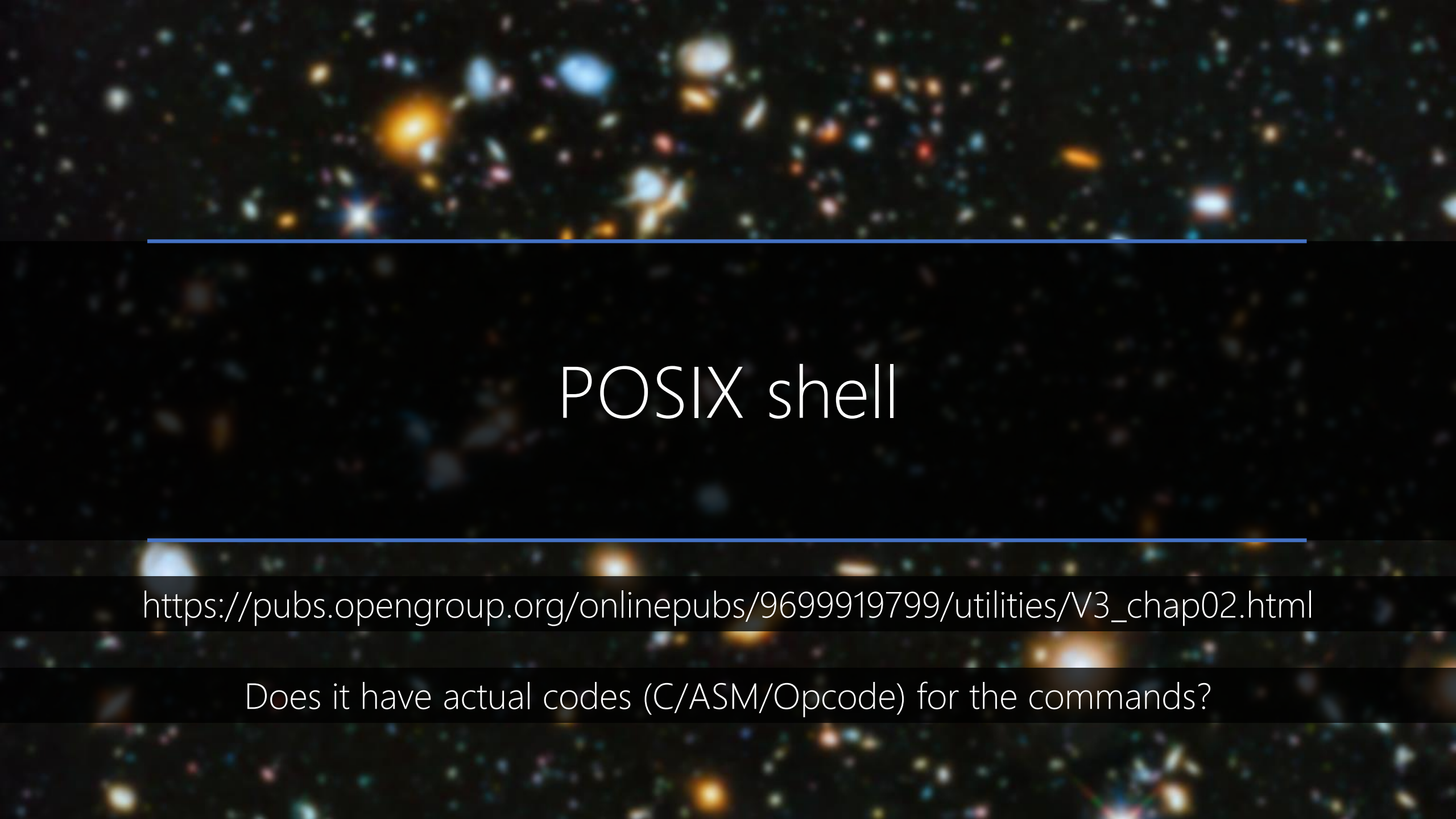

The shell from who?
UNIX, BSD, Linux, Darwin, Minix, ....

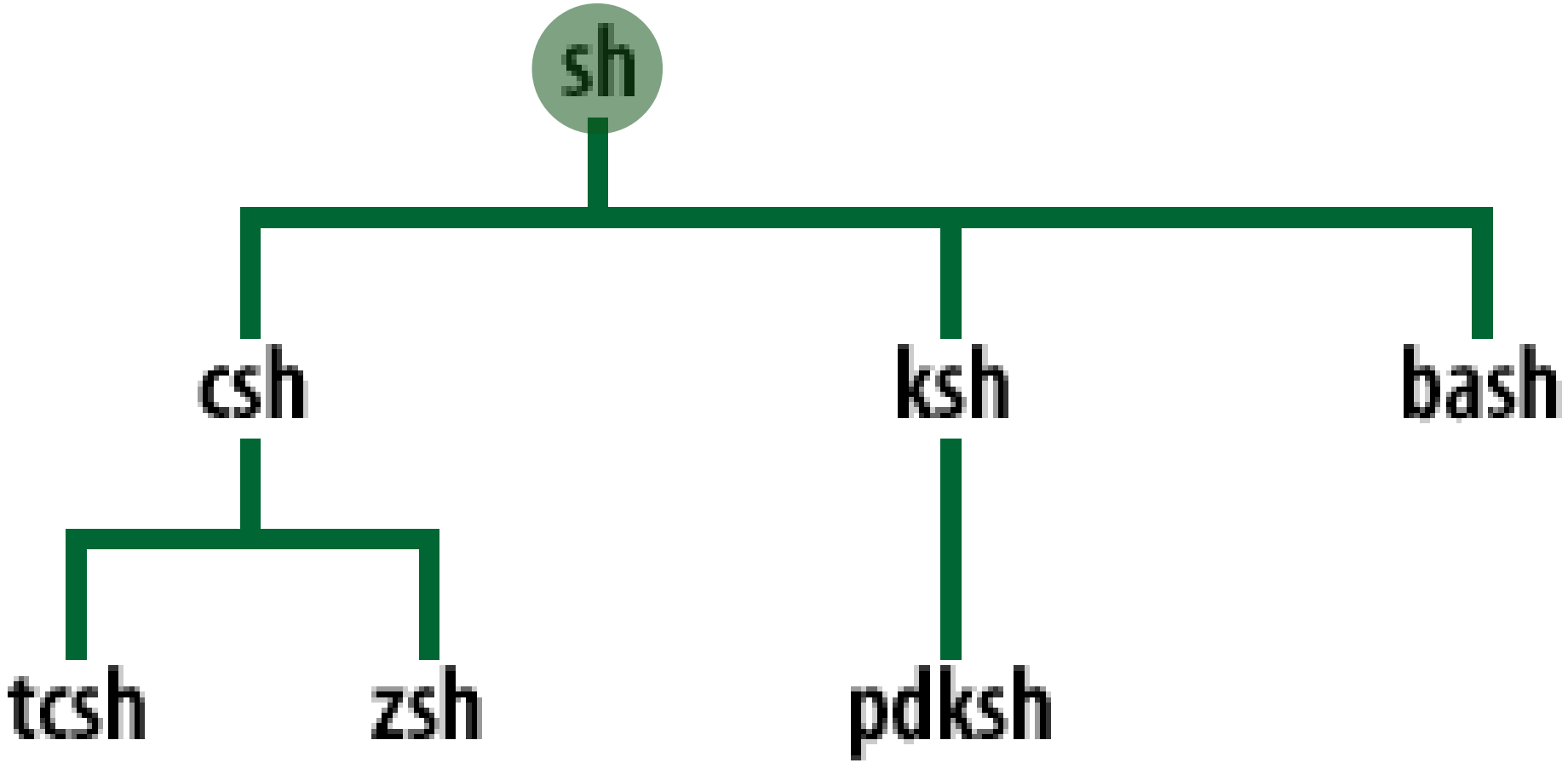

POSIX shell
https://pubs.opengroup.org/onlinepubs/9699919799/utilities/V3_chap02.html



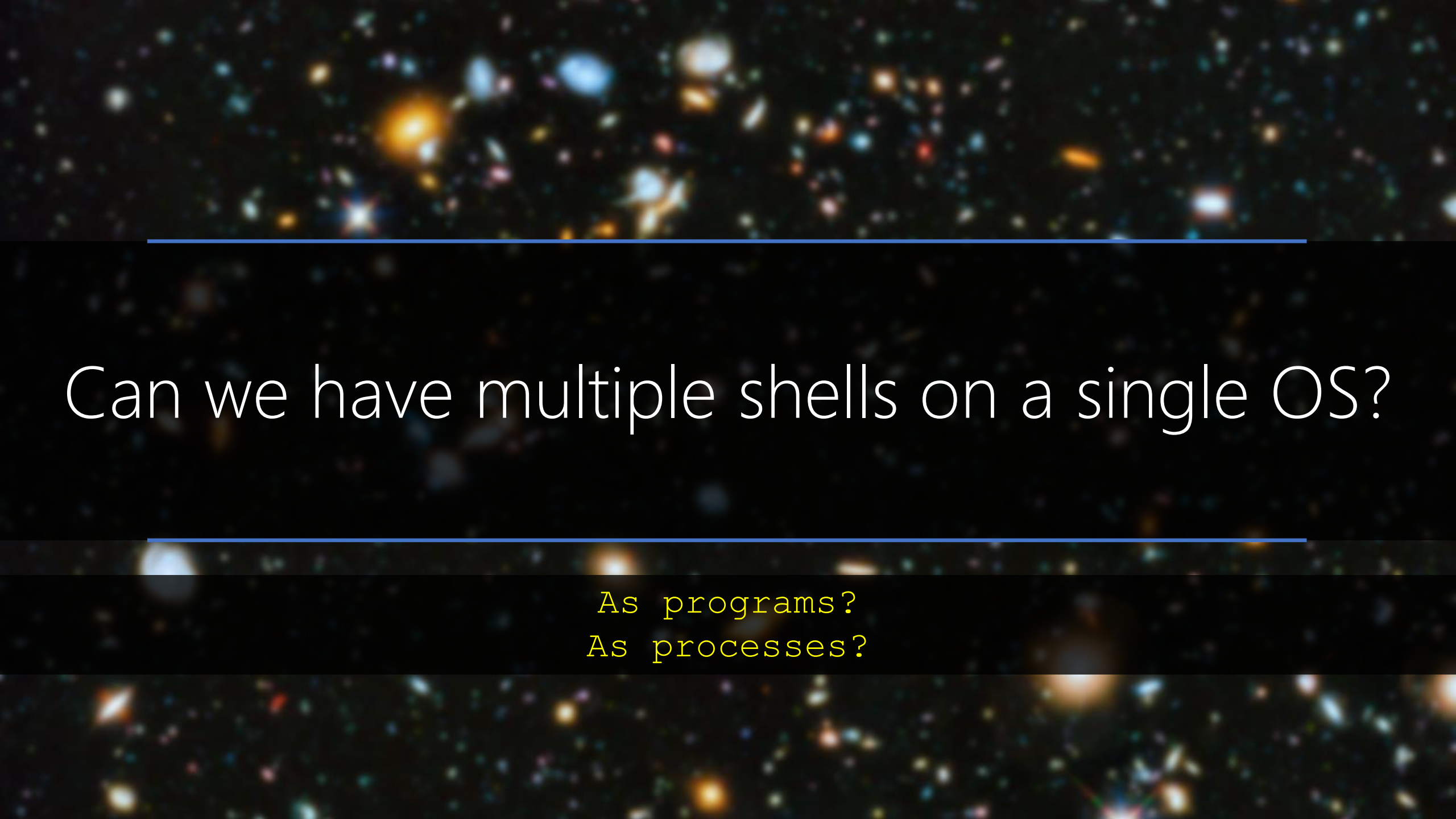
# POSIX shell

| | |
|---|---|
| `ls` | (list, originally in Multics, Nov. 3, 1971) |
| `cd` | (change directory) |
| `cat` | (concatenate) |
| `kill` | |
| `echo` | |
| `exit` | |
| … | |


POSIX shell
https://pubs.opengroup.org/onlinepubs/9699919799/utilities/V3_chap02.html
Does it have actual codes (C/ASM/Opcode) for the commands?

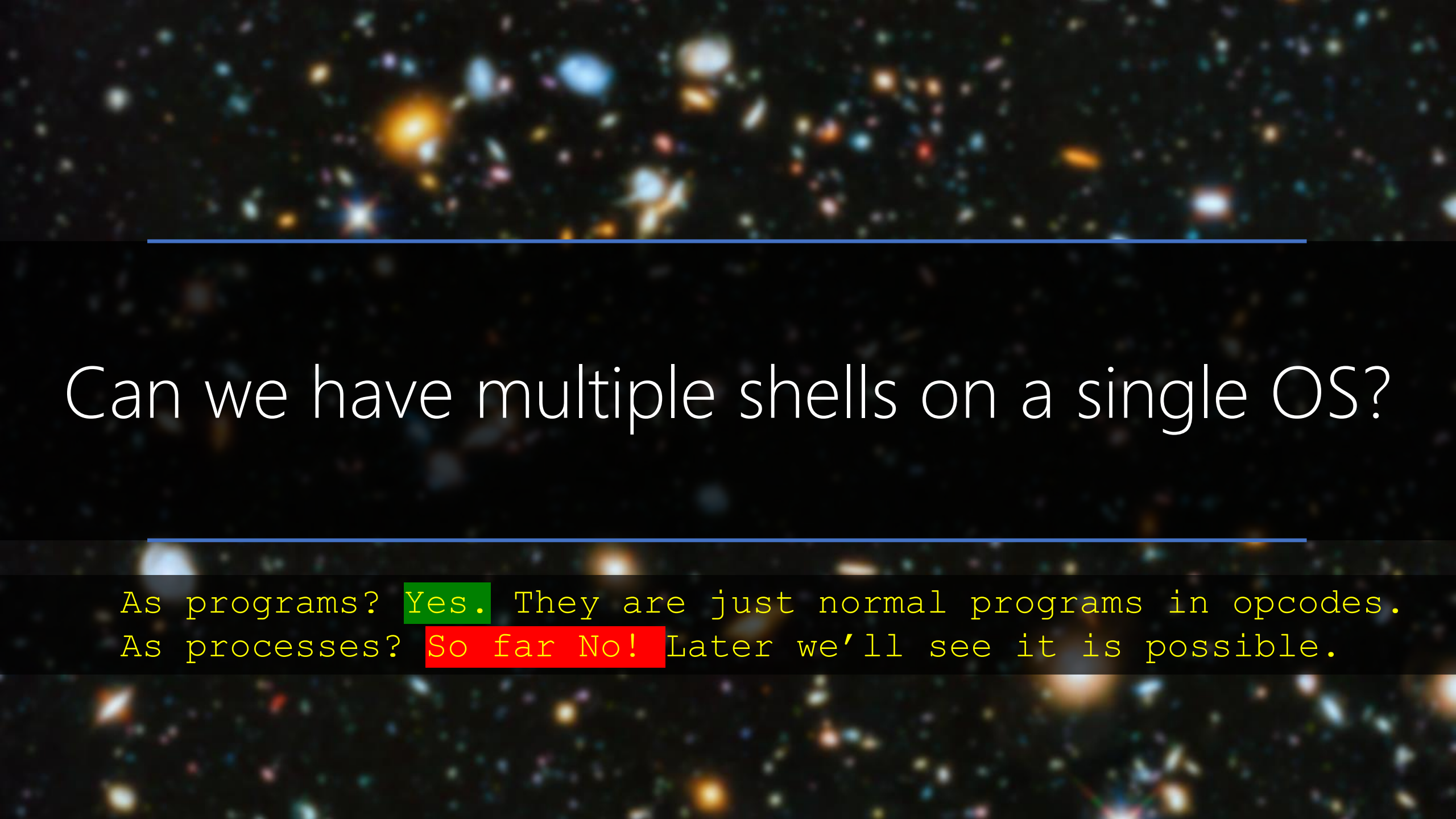



| Name | Path | FreeBSD 8.0 | Linux 3.2.0 | Mac OS X 10.6.8 | Solaris 10 |
|---|---|---|---|---|---|
| Bourne shell | `/bin/sh` | • | • | copy of `bash` | • |
| Bourne-again shell | `/bin/bash` | optional | • | • | • |
| C shell | `/bin/csh` | link to `tcsh` | optional | link to `tcsh` | • |
| Korn shell | `/bin/ksh` | optional | optional | • | • |
| TENEX C shell | `/bin/tcsh` | • | optional | • | • |



# Can we have multiple shells on a single OS?

As programs?
As processes?



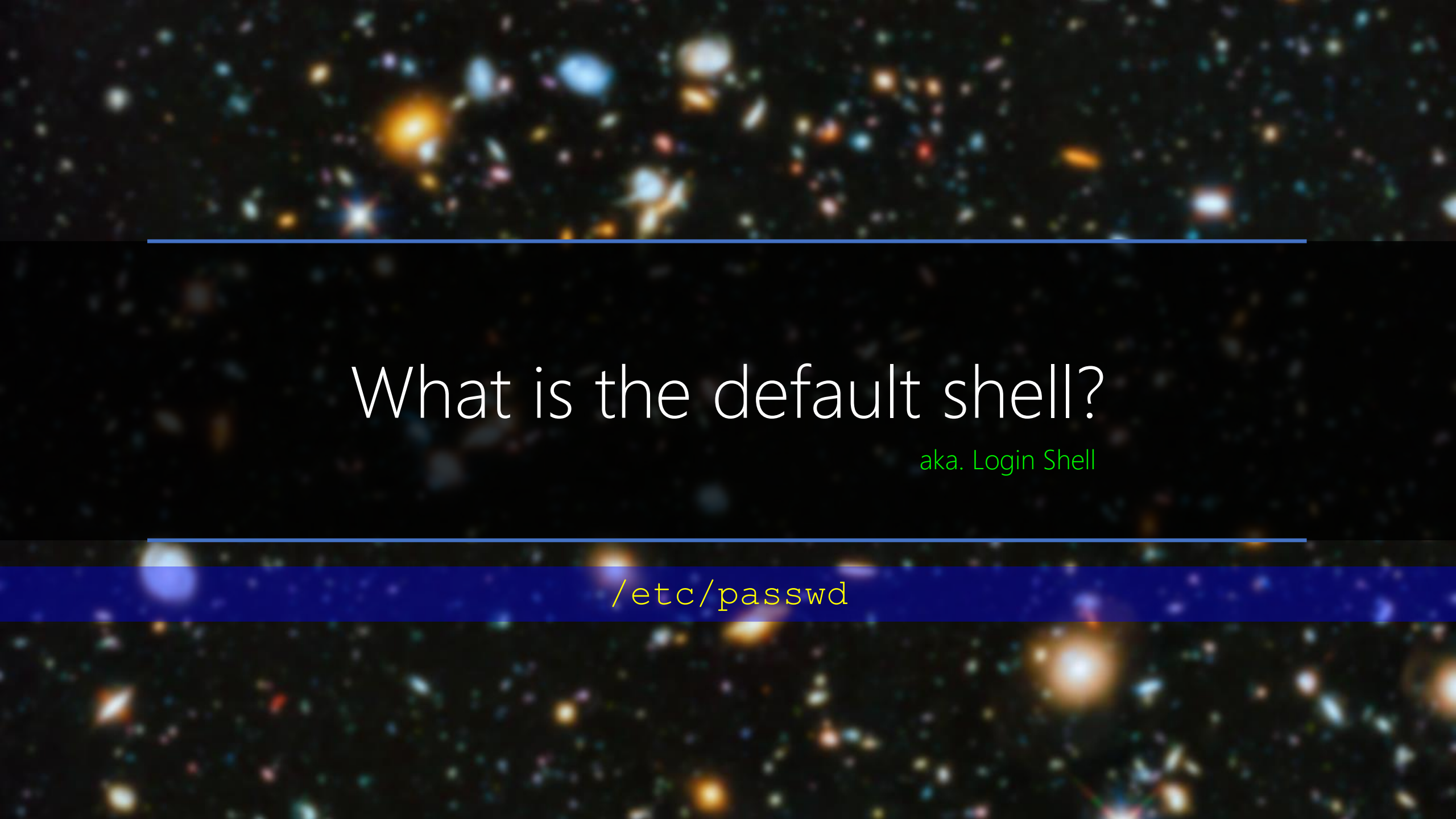
# Can we have multiple shells on a single OS?

As programs? Yes. They are just normal programs in opcodes.
As processes? So far No! Later we'll see it is possible.

# List of available shells?

`/etc/shells`

```
hfani@alpha:~$ vi /etc/shells
# /etc/shells: valid login shells
/bin/sh
/bin/dash
/bin/bash
/bin/rbash
/usr/bin/screen
/usr/bin/tmux
/bin/mksh
/bin/mksh-static
/usr/lib/klibc/bin/mksh-static
~
~
~
~
~
~
~
~
~
~
~
~
~
~
~
~
~
```



# What is the default shell?

aka. Login Shell

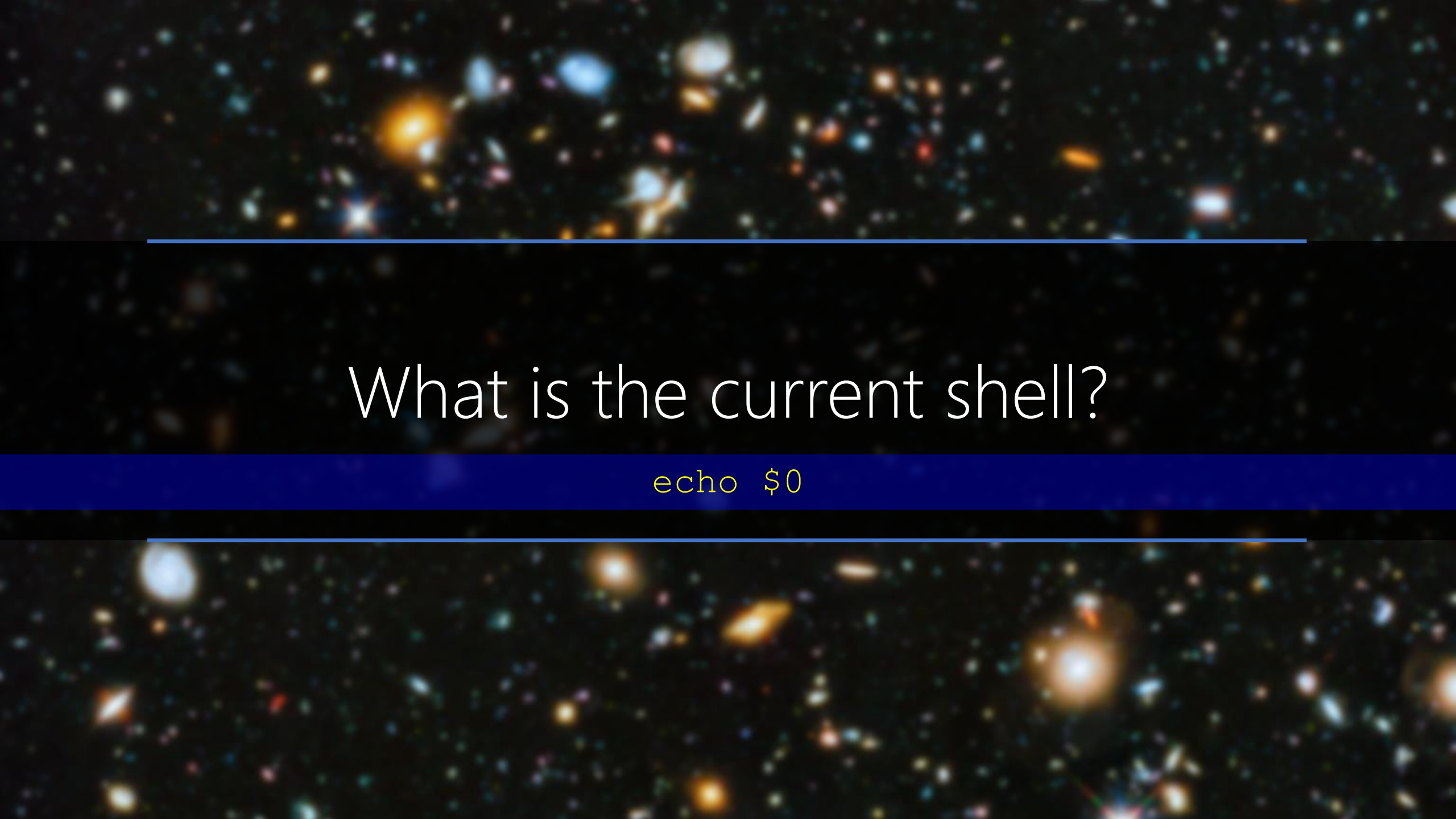
`/etc/passwd`

```
hfani@alpha:~$ vi /etc/passwd
root:x:0:0:root:/root:/bin/bash
daemon:x:1:1:daemon:/usr/sbin:/usr/sbin/nologin
bin:x:2:2:bin:/bin:/usr/sbin/nologin
sys:x:3:3:sys:/dev:/usr/sbin/nologin
sync:x:4:65534:sync:/bin:/bin/sync
games:x:5:60:games:/usr/games:/usr/sbin/nologin
man:x:6:12:man:/var/cache/man:/usr/sbin/nologin
lp:x:7:7:lp:/var/spool/lpd:/usr/sbin/nologin
mail:x:8:8:mail:/var/mail:/usr/sbin/nologin
news:x:9:9:news:/var/spool/news:/usr/sbin/nologin
uucp:x:10:10:uucp:/var/spool/uucp:/usr/sbin/nologin
proxy:x:13:13:proxy:/bin:/usr/sbin/nologin
www-data:x:33:33:www-data:/var/www:/usr/sbin/nologin
backup:x:34:34:backup:/var/backups:/usr/sbin/nologin
list:x:38:38:Mailing List Manager:/var/list:/usr/sbin/nologin
irc:x:39:39:ircd:/run/ircd:/usr/sbin/nologin
gnats:x:41:41:Gnats Bug-Reporting System (admin):/var/lib/gnats:/usr/sbin/nologin
nobody:x:65534:65534:nobody:/nonexistent:/usr/sbin/nologin
systemd-timesync:x:100:103:systemd Time Synchronization,,,:/run/systemd:/bin/false
systemd-network:x:101:104:systemd Network Management,,,:/run/systemd/netif:/bin/false
systemd-resolve:x:102:105:systemd Resolver,,,:/run/systemd/resolve:/bin/false
messagebus:x:104:109::/var/run/dbus:/bin/false
pulse:x:105:110:PulseAudio daemon,,,:/var/run/pulse:/bin/false
avahi:x:106:114:Avahi mDNS daemon,,,:/var/run/avahi-daemon:/bin/false
Debian-exim:x:107:116::/var/spool/exim4:/bin/false
statd:x:108:65534::/var/lib/nfs:/bin/false
colord:x:109:120:colord colour management daemon,,,:/var/lib/colord:/bin/false
```

*Default shell for the user root*

*Are these shell?!*

*Where is Hossein's default shell?*



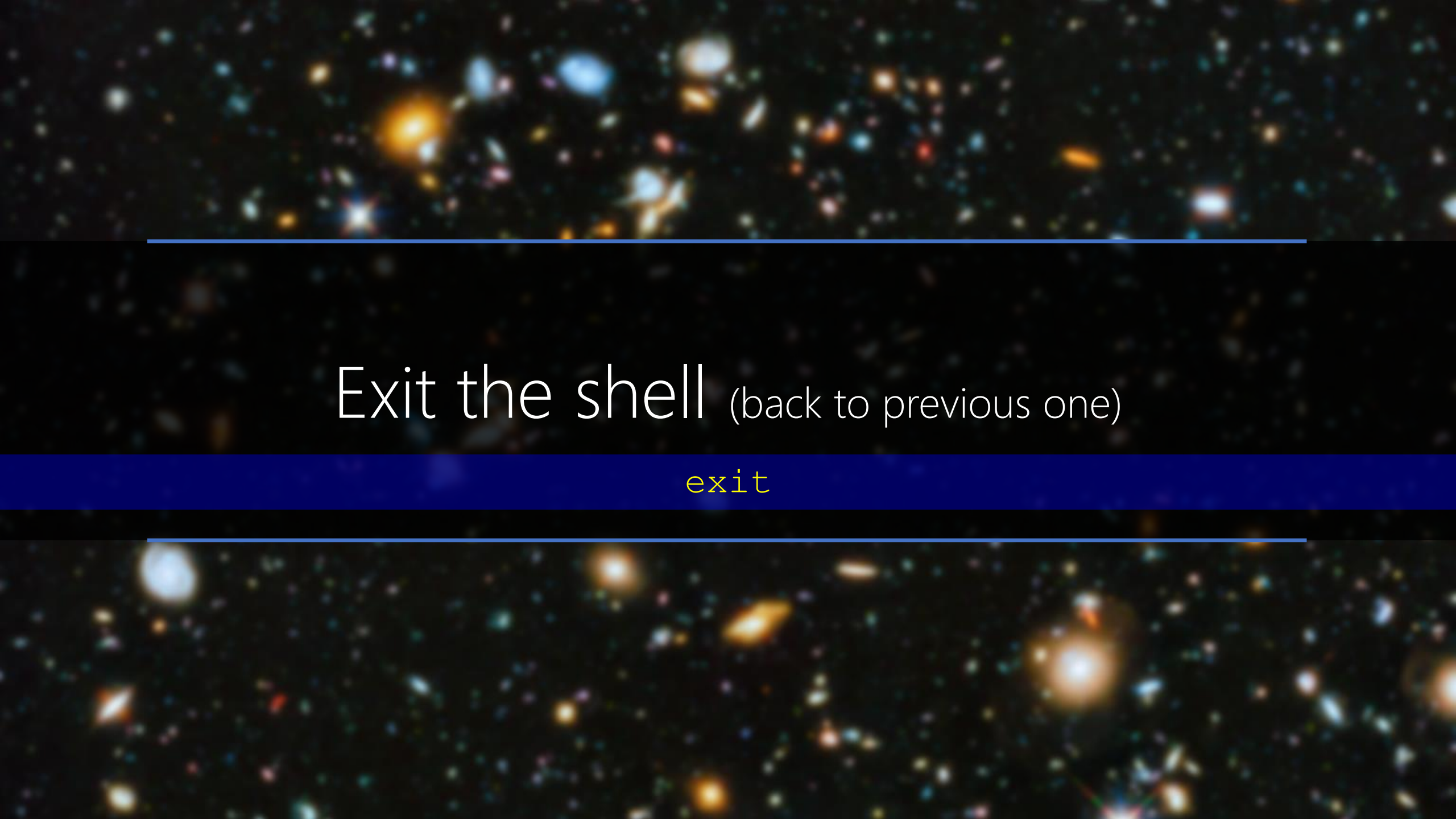
# What is the current shell?

```
echo $0
```

```
hfani@alpha:~$ echo $0
-bash
```


Change the shell
{name of the shell}

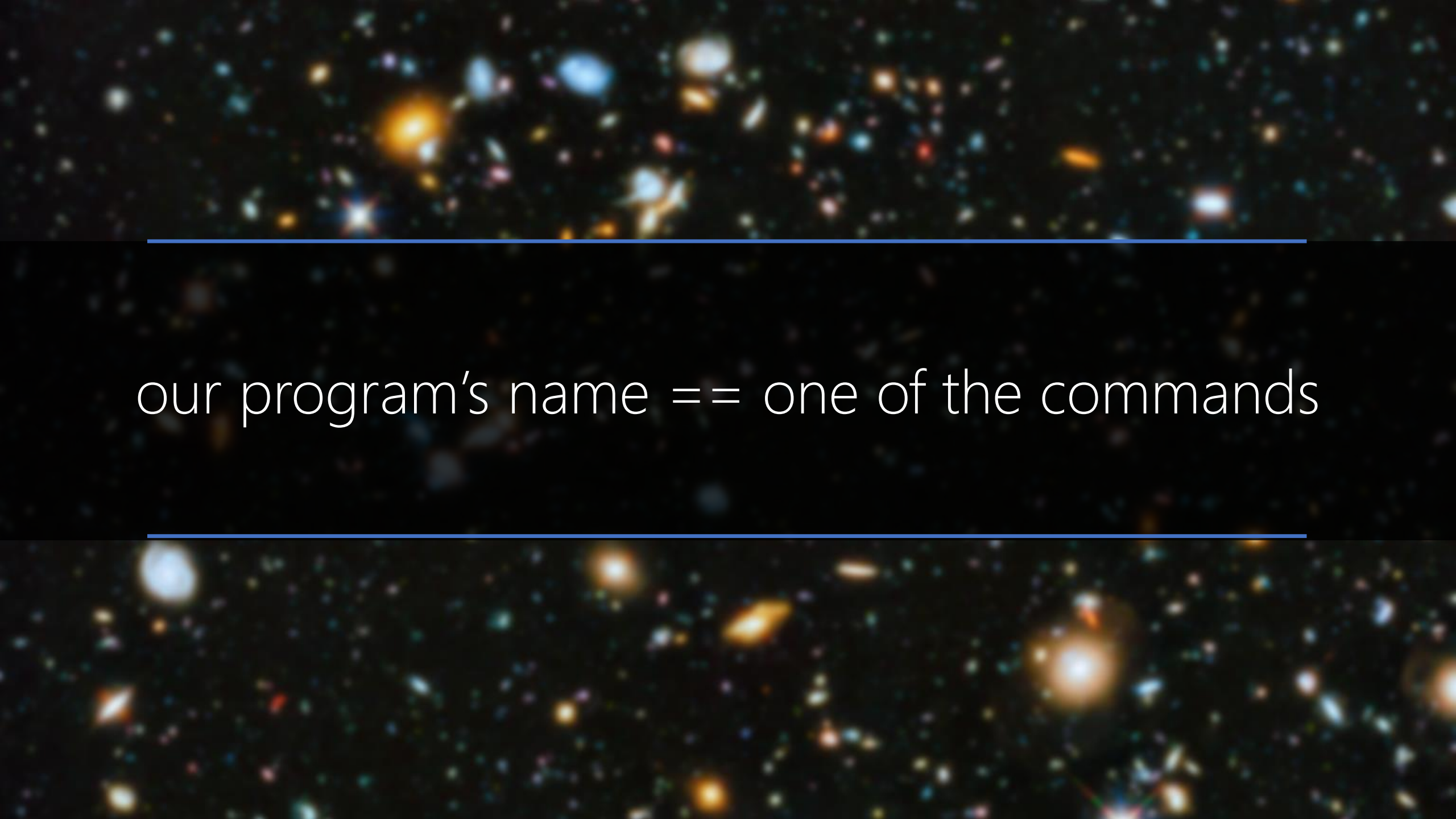
```
hfani@alpha:~$ echo $0
-bash
hfani@alpha:~$ sh
\[\e]0;\u@\h: \w\a\]\[\033[01;32m\]\u@\h\[\033[00m\]:\[\033[01;34m\]\w\[\033[00m\]$ echo $0
sh
```



# Exit the shell (back to previous one)

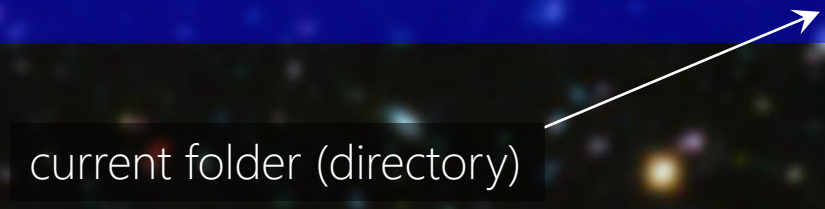
```
exit
```

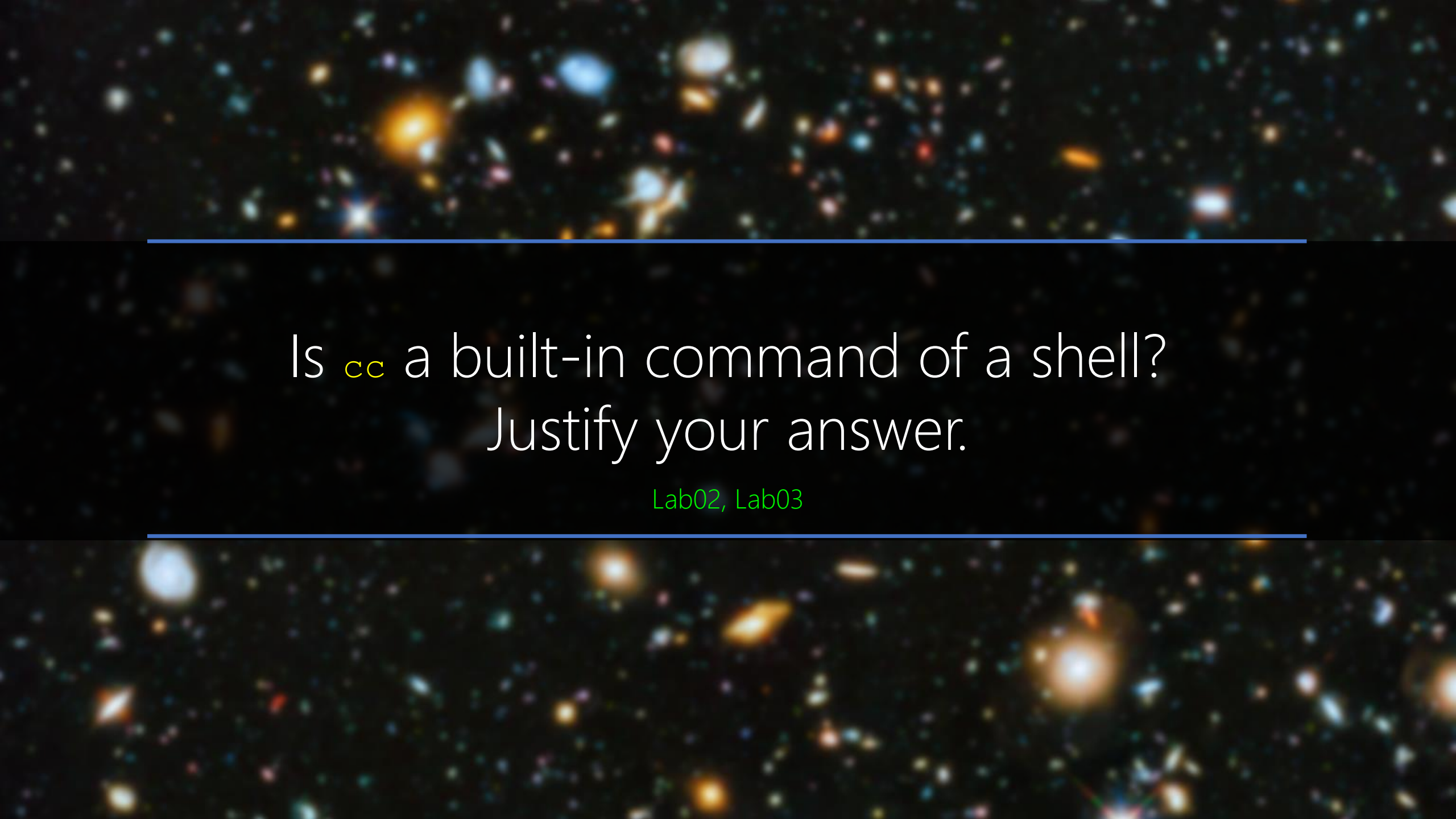
```
hfani@alpha:~$ echo $0
-bash
hfani@alpha:~$ sh
\[\e]0;\u@\h: \w\a\]\[\033[01;32m\]\u@\h\[\033[00m\]:\[\033[01;34m\]\w\[\033[00m\]$ echo $0
sh
\[\e]0;\u@\h: \w\a\]\[\033[01;32m\]\u@\h\[\033[00m\]:\[\033[01;34m\]\w\[\033[00m\]$ exit
hfani@alpha:~$ echo $0
-bash
hfani@alpha:~$
```


our program’s name == one of the commands

# our program's name == one of the commands

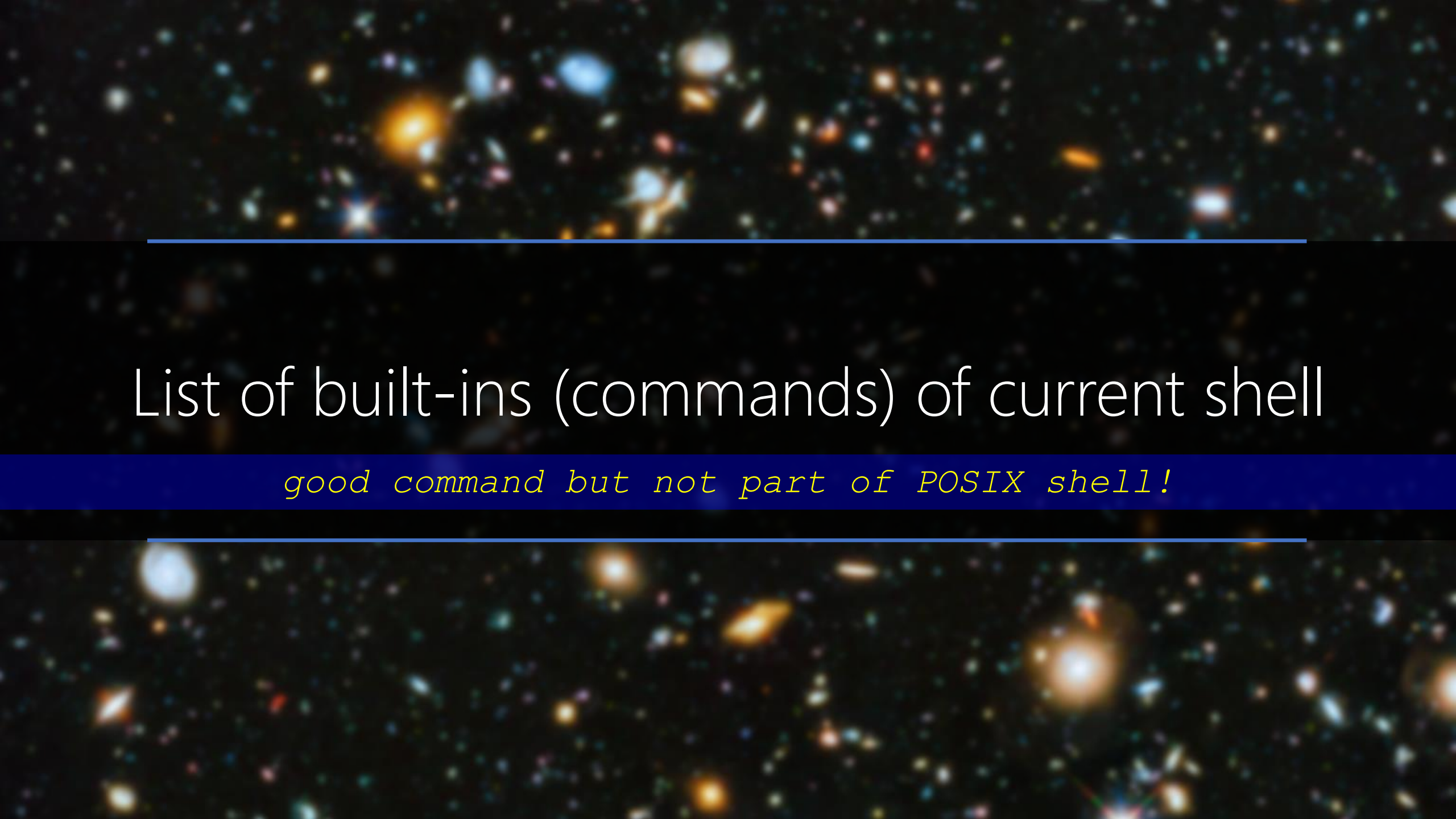
```
echo
./echo
```





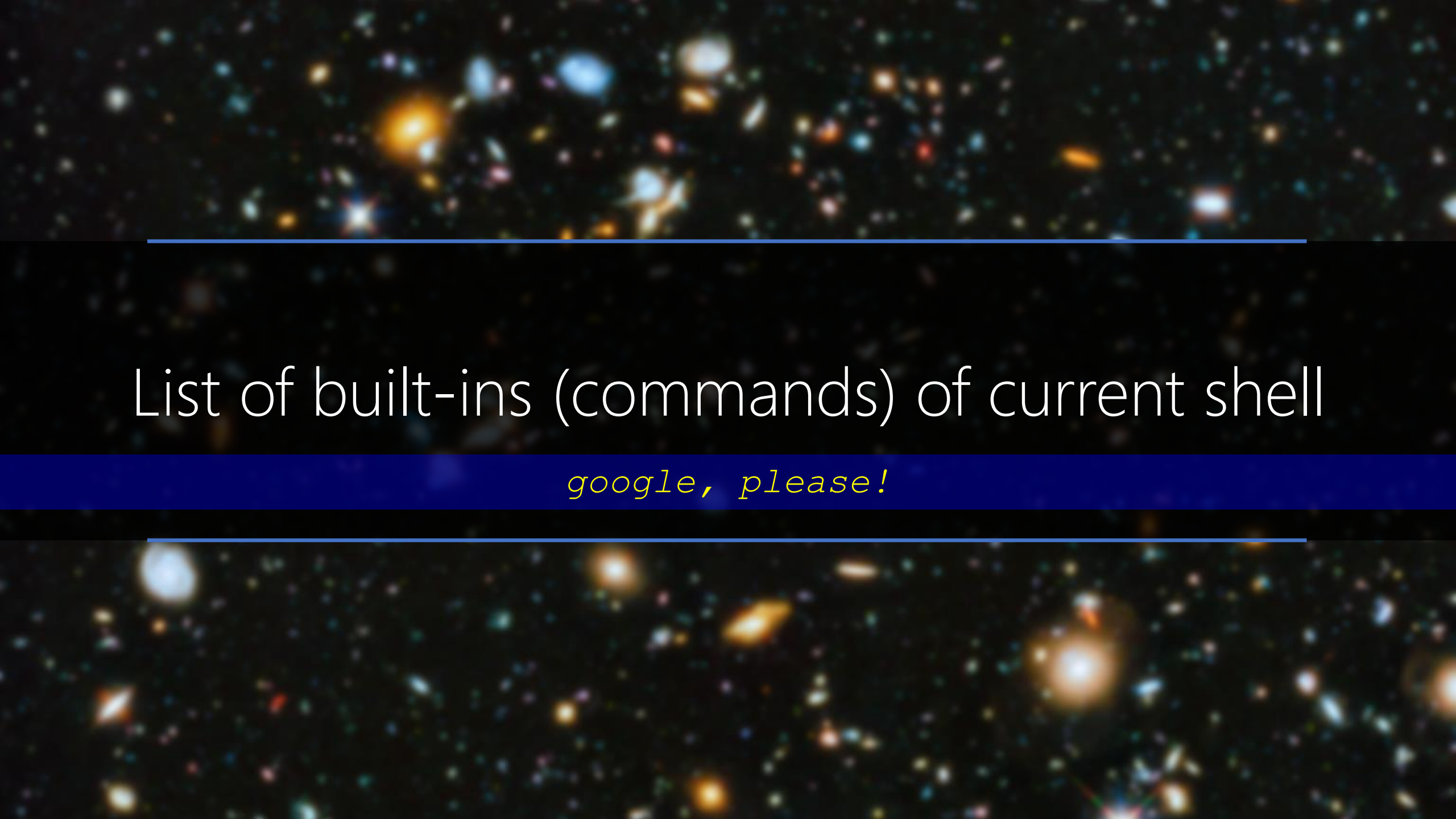
# Is `cc` a built-in command of a shell? Justify your answer.

Lab02, Lab03



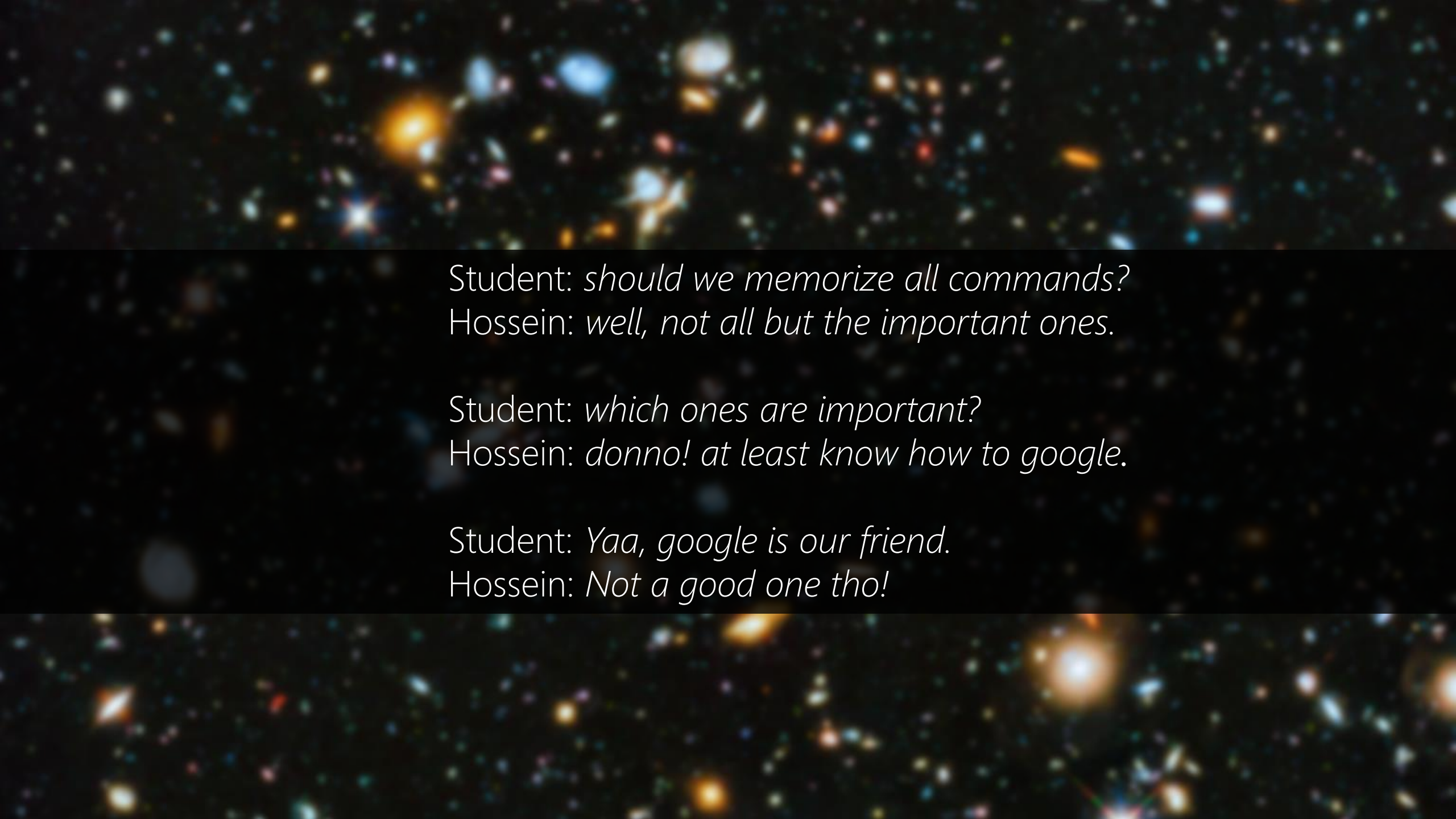
# List of built-ins (commands) of current shell

*good command but not part of POSIX shell!*



# List of built-ins (commands) of current shell

*google, please!*



Student: *should we memorize all commands?*
Hossein: *well, not all but the important ones.*

Student: *which ones are important?*
Hossein: *donno! at least know how to google.*

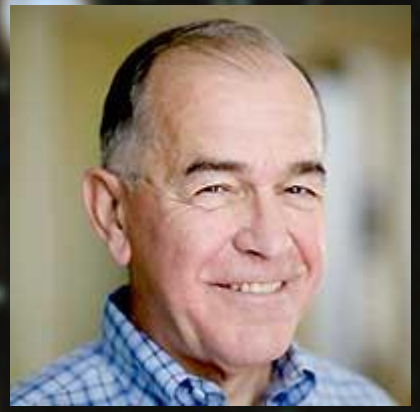
Student: *Yaa, google is our friend.*
Hossein: *Not a good one tho!*

# Which shell is the best?

The one with a lot of commands but slow?
The one with few commands but fast?
The one with cool features?
The one which is colorful?
The one with Graphical User Interface (GUI)?

# Which shell is the best?

`sh`



Stephen Richard "Steve" Bourne

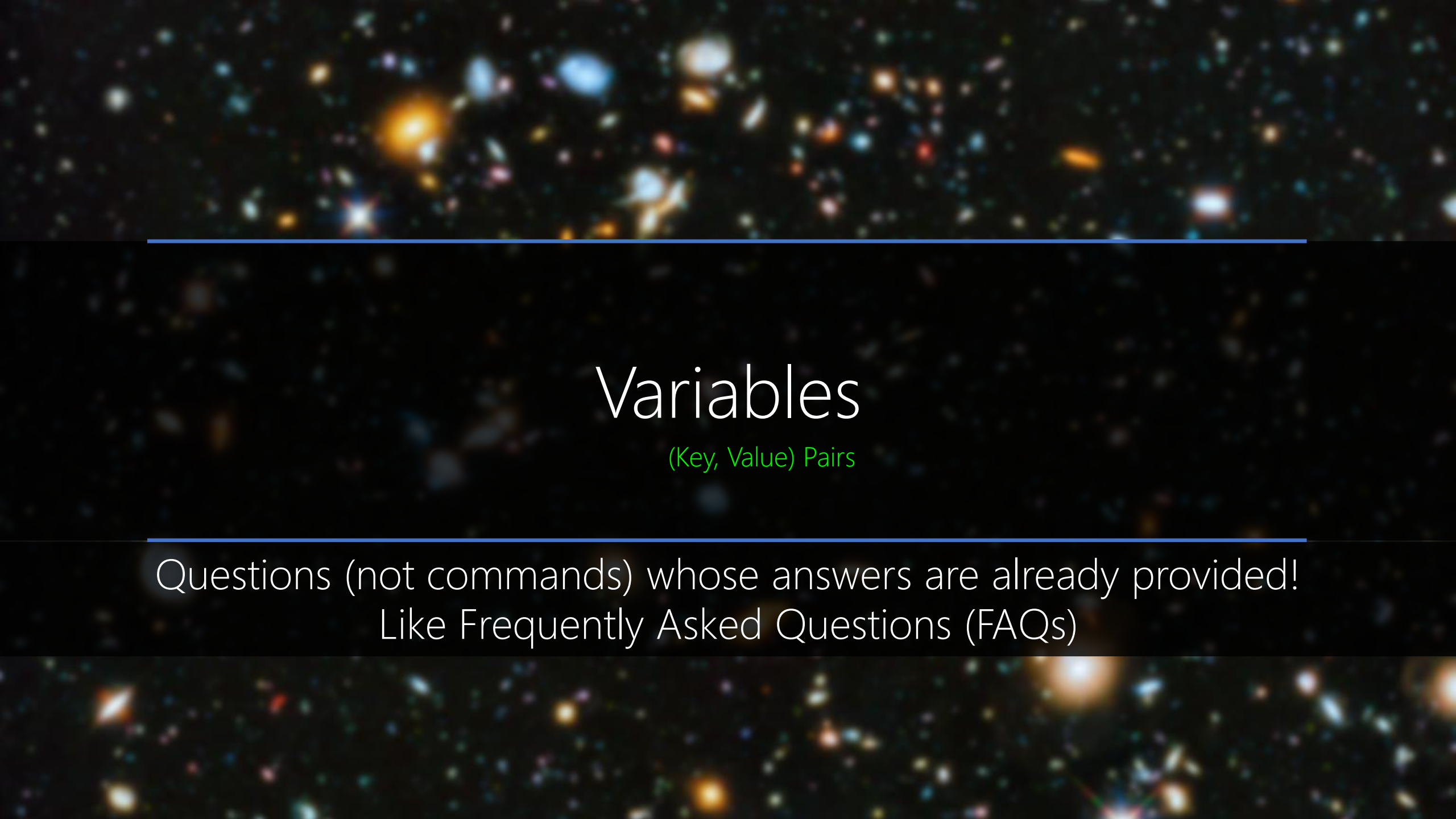
- Bell Labs
- The first shell
- minimal, chosen as standard (POSIX)

# Which shell is the best?

`bash`

## Brian Jhan Fox

- Bourne again (born again) sh
- GNU project
- Default for most Linux distributions
- Available alternative in macOS
- https://www.gnu.org/software/bash/manual/bash.html
- https://ftp.gnu.org/gnu/bash/



# Variables

(Key, Value) Pairs

Questions (not commands) whose answers are already provided!
Like Frequently Asked Questions (FAQs)

# System Variables

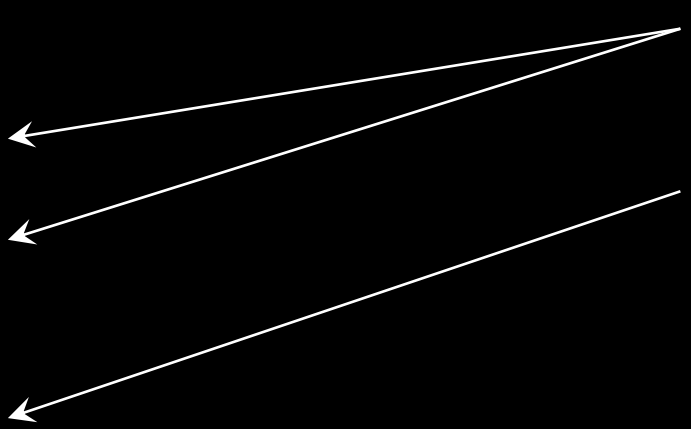
aka. Environment Variables, Global Variables, Unix Variables

Hossein: Kernel Variables

By convention, keys are UPPERCASE

To see the value, `echo ${KEY}`

```
hfani@alpha:~$ echo $OSTYPE
linux-gnu
hfani@alpha:~$ echo $USER
hfani
hfani@alpha:~$ echo $LOGNAME
hfani
hfani@alpha:~$ echo $HOME
/home/hfani
hfani@alpha:~$ echo $HOST

hfani@alpha:~$ echo $DISPLAY

hfani@alpha:~$ echo $EDITOR

hfani@alpha:~$ echo $SHELL
/bin/bash
hfani@alpha:~$ echo $PATH
/usr/local/bin:/usr/bin:/bin:/usr/local/games:/usr/games:/opt/maple2021/bin:/opt/netlogo:/
ome/hfani/.dotnet/tools
hfani@alpha:~$
```



*Not Set! Unset.*

*An important one! Very important actually.*

# PATH

Colon(:)-delimited list of directories

Tells the shell where to look/search when you request a particular program

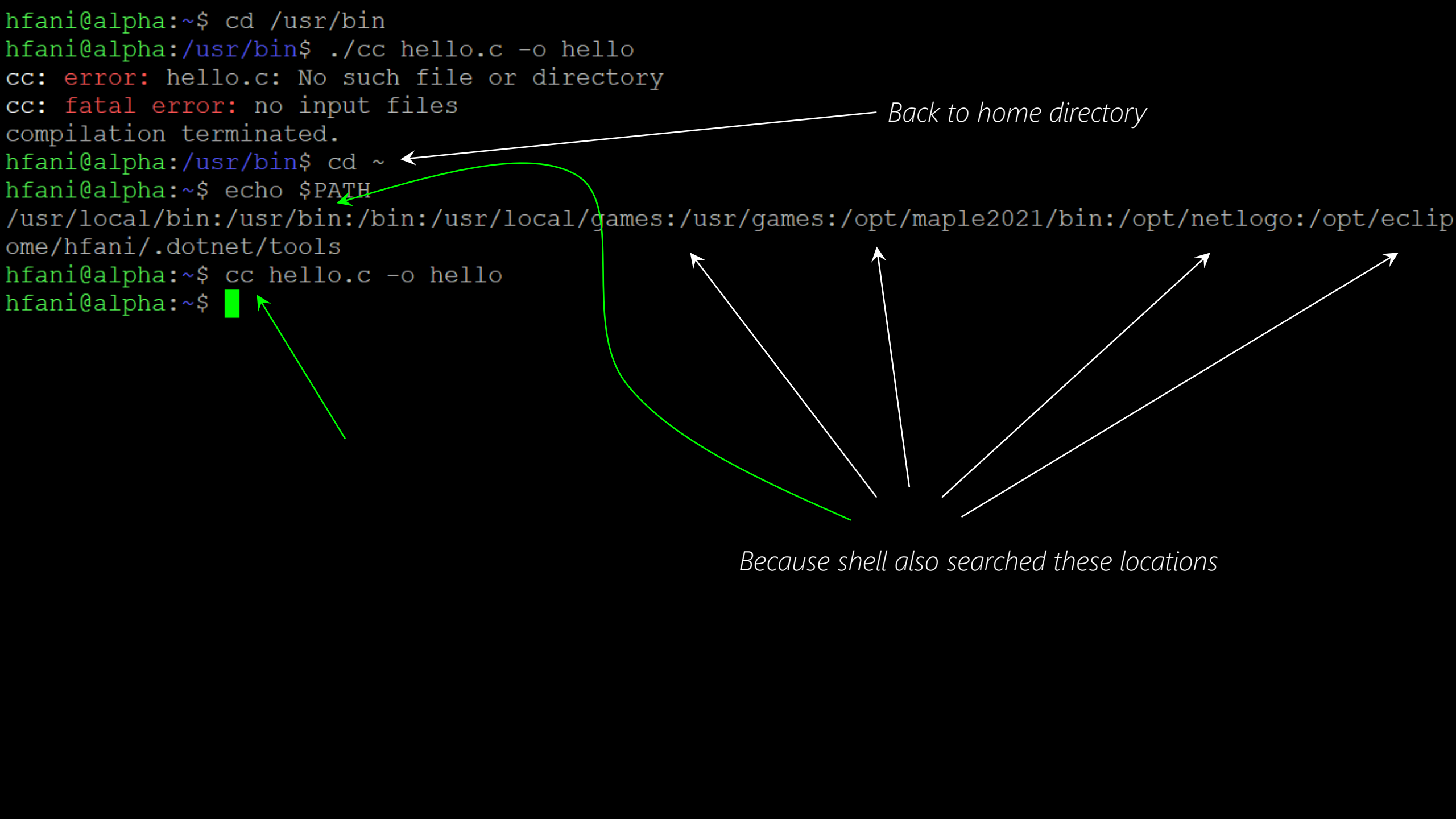
```
hfani@alpha:~$ cd /usr/bin
hfani@alpha:/usr/bin$ ./cc hello.c -o hello
cc: error: hello.c: No such file or directory
cc: fatal error: no input files
compilation terminated.
hfani@alpha:/usr/bin$
```

*The actual location of program file for C compiler*

*Either you have to copy your files to /usr/bin*
*Or copy cc to your directory*

*Both are impossible due to lack of administrative privileges*

```
hfani@alpha:~$ cd /usr/bin
hfani@alpha:/usr/bin$ ./cc hello.c -o hello
cc: error: hello.c: No such file or directory
cc: fatal error: no input files
compilation terminated.
hfani@alpha:/usr/bin$ cd ~
hfani@alpha:~$ echo $PATH
/usr/local/bin:/usr/bin:/bin:/usr/local/games:/usr/games:/opt/maple2021/bin:/opt/netlogo:/opt/eclip
ome/hfani/.dotnet/tools
hfani@alpha:~$ cc hello.c -o hello
hfani@alpha:~$
```

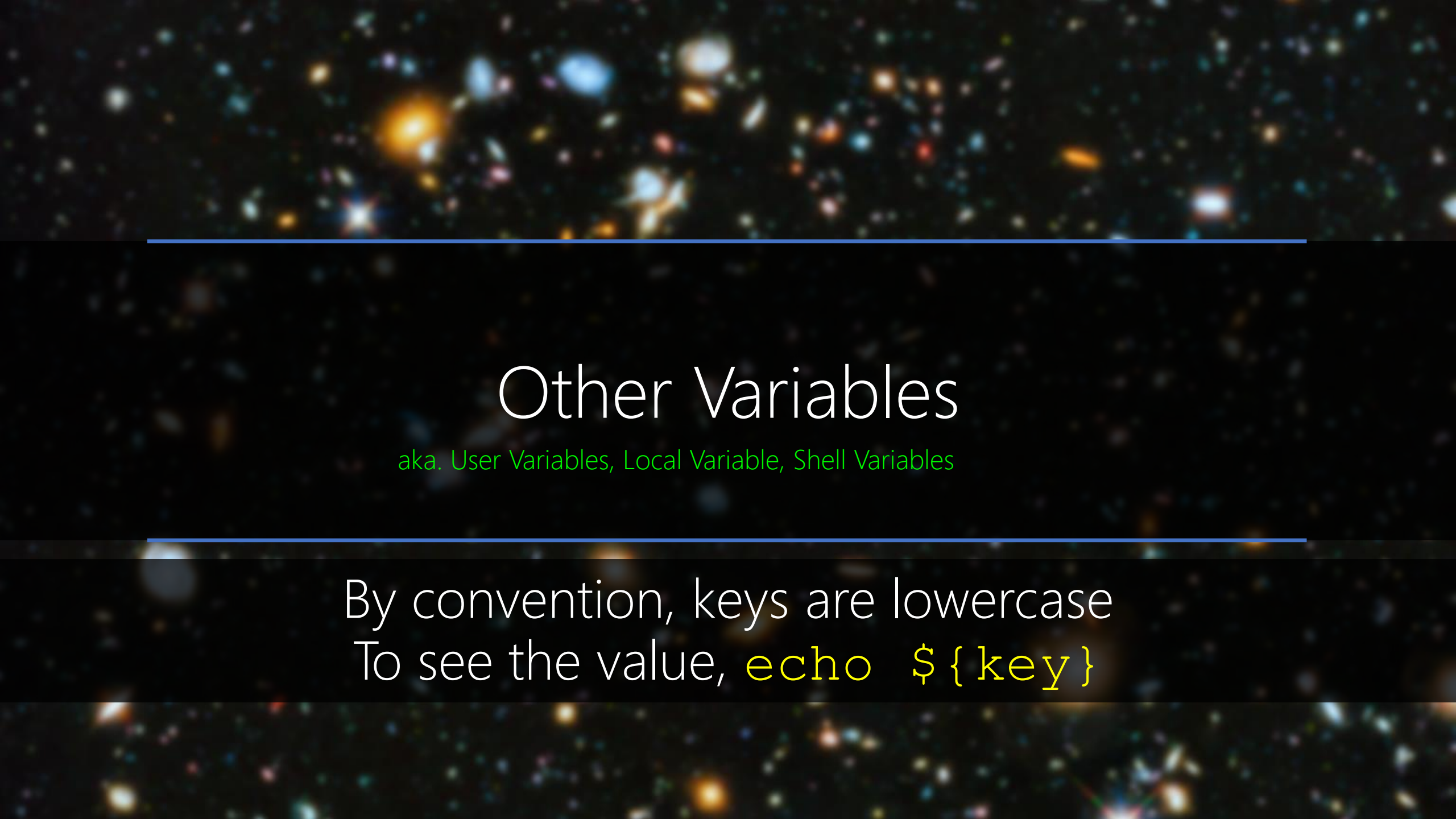


# System Variables

aka. Environment Variables, Global Variables, Unix Variables

Hossein: Kernel Variables

Is it able to modify the KEY's value? Yes.
Is it able to unset the KEY's value? Yes.
Is it able to add a new KEY=Value pair? Yes.
Is it able to persist the change? Yes.
How? It depends on the shell ☹

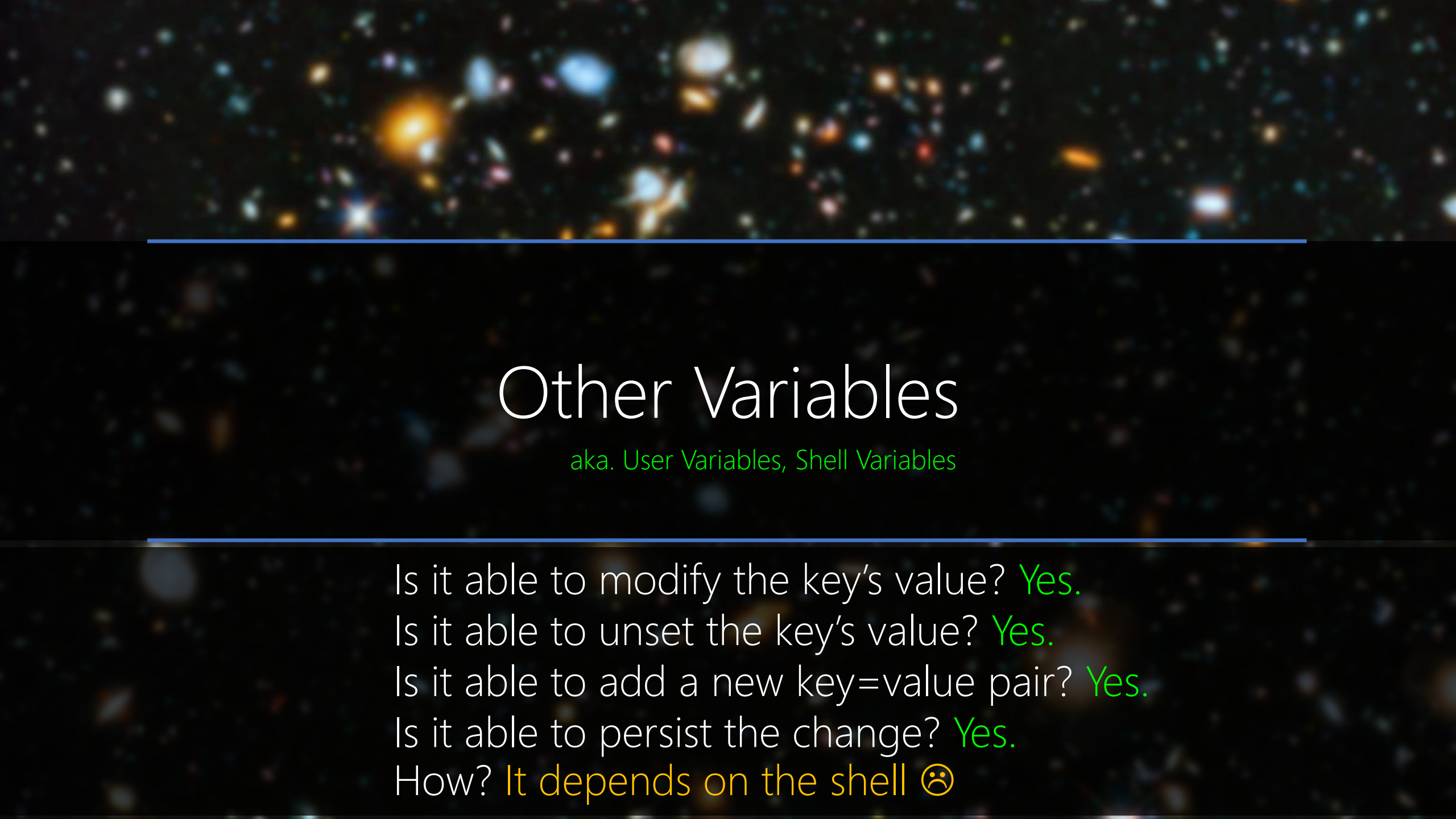


# Other Variables

aka. User Variables, Local Variable, Shell Variables

By convention, keys are lowercase

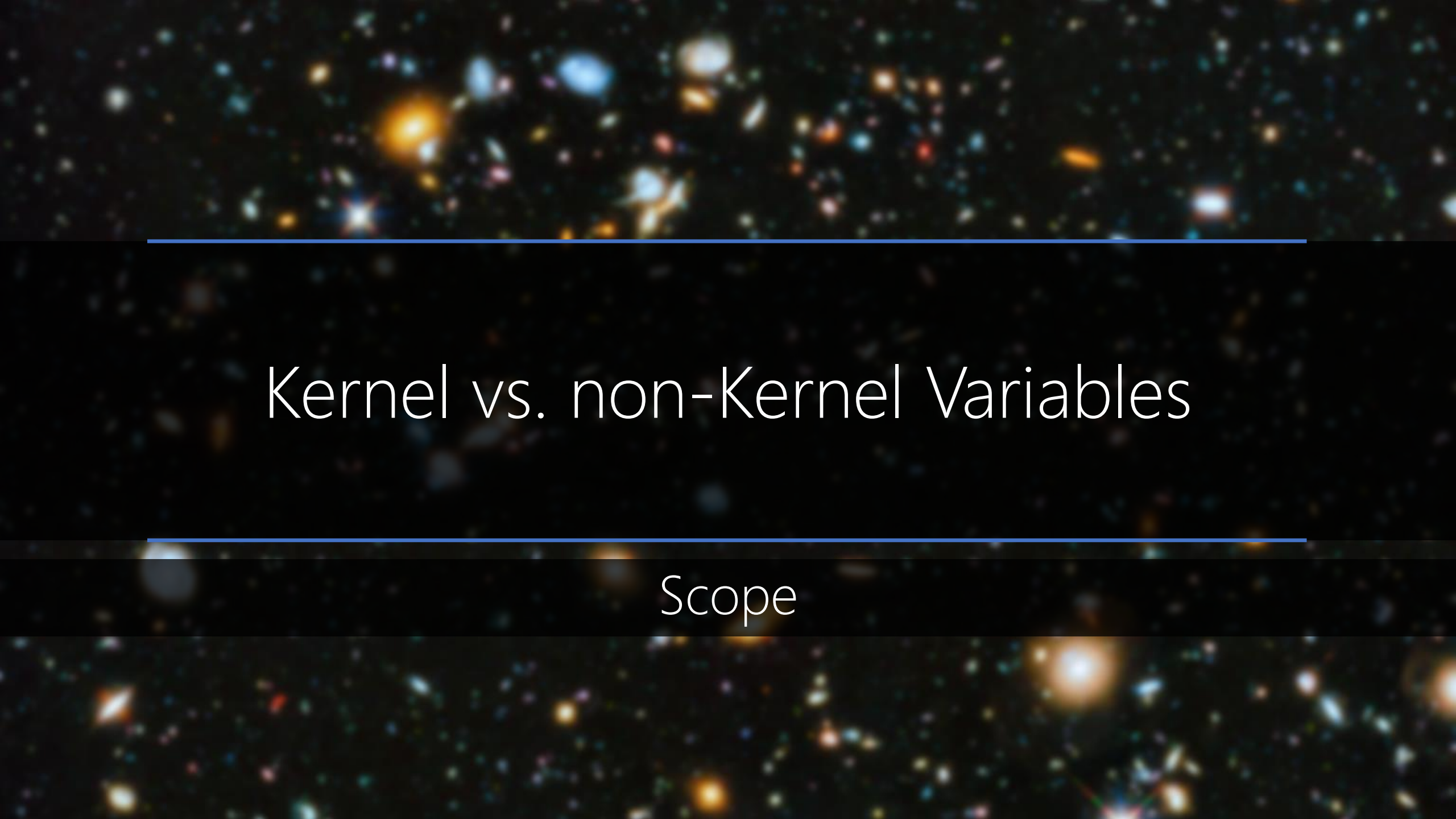
To see the value, `echo ${key}`



# Other Variables

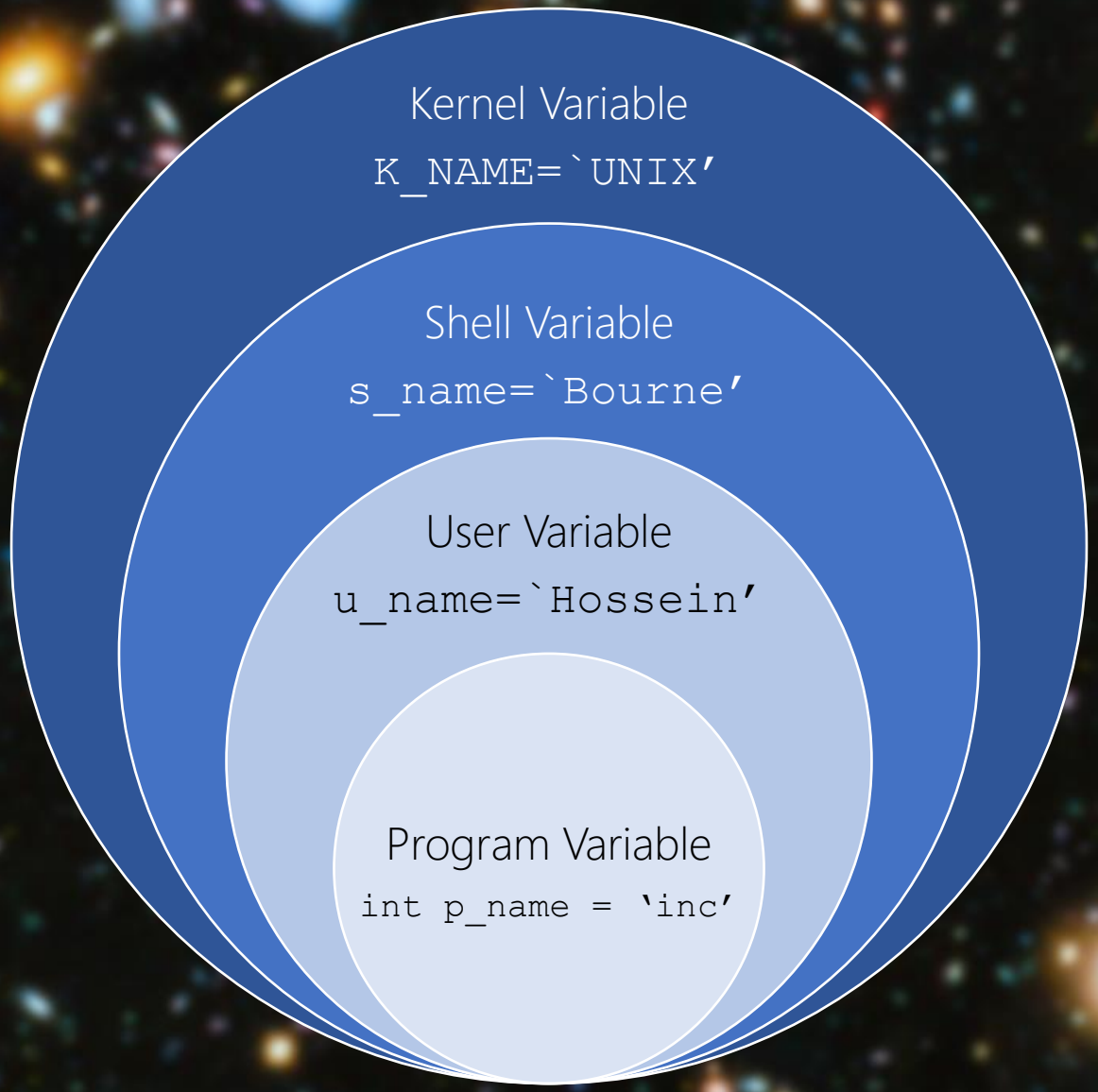
aka. User Variables, Shell Variables

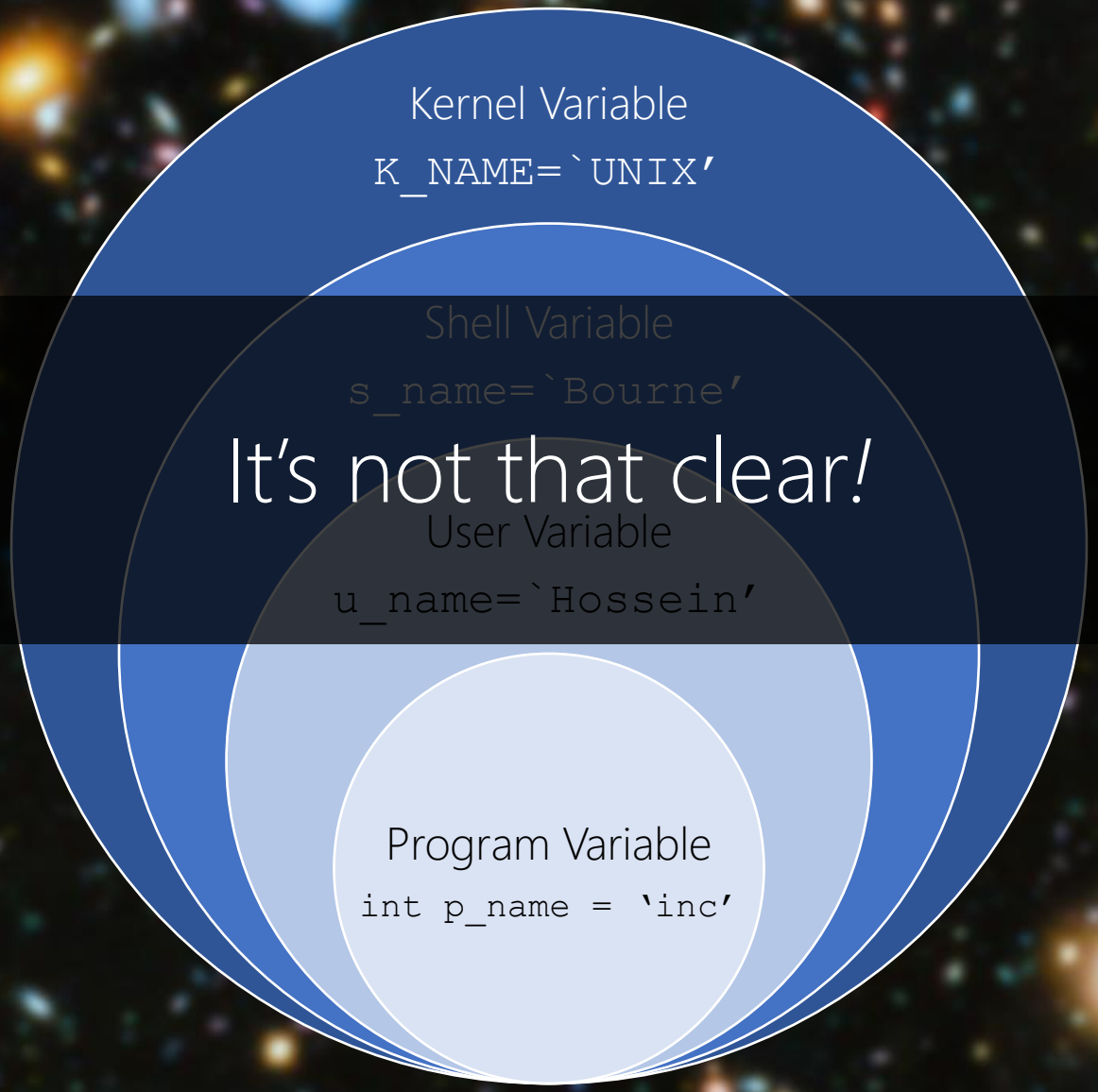
Is it able to modify the key's value? Yes.
Is it able to unset the key's value? Yes.
Is it able to add a new key=value pair? Yes.
Is it able to persist the change? Yes.
How? It depends on the shell ☹



# Kernel vs. non-Kernel Variables

## Scope


Kernel Variable
K_NAME=`UNIX'
Shell Variable
s_name=`Bourne'
User Variable
u_name=`Hossein'
Program Variable
int p_name = 'inc'


Kernel Variable
K_NAME=`UNIX'
Shell Variable
s_name=`Bourne'
It's not that clear!
User Variable
u_name=`Hossein'
Program Variable
int p_name = 'inc'

# Access Kernel Variables by Call to Library Routine

Lab02

```
#include <stdlib.h>;
char *getenv(const char *KEY)
```

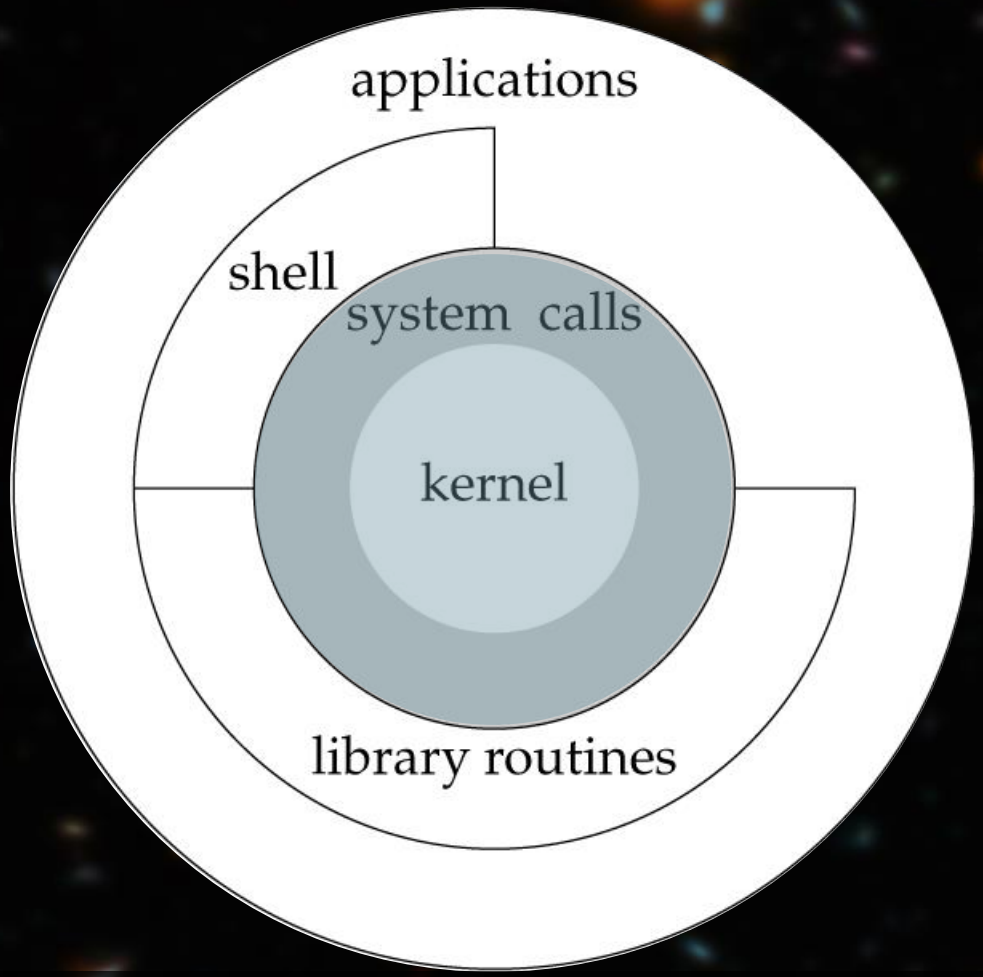
```c
#include <stdio.h>
#include <time.h>
#include <stdlib.h>
int main()
{
  printf("Hello World! This is hfani@uwindsor.ca, StudentID: 123456789\n");
  time_t t = time(NULL);
  struct tm tm = *localtime(&t);
  printf("now: %d-%02d-%02d %02d:%02d:%02d\n", tm.tm_year + 1900, tm.tm_mon + 1, tm.tm_m
  printf("%s@shell:%s$\n", getenv("USER"),getenv("PWD"));

}
```

*The library routine that does system call to Kernel*
*Your program statically linked this library!*

*Getting the values of USER and PWD (path of working directory)*

# Access Kernel Variables by System Call

```
#include <unistd.h>;
extern char **environ
```

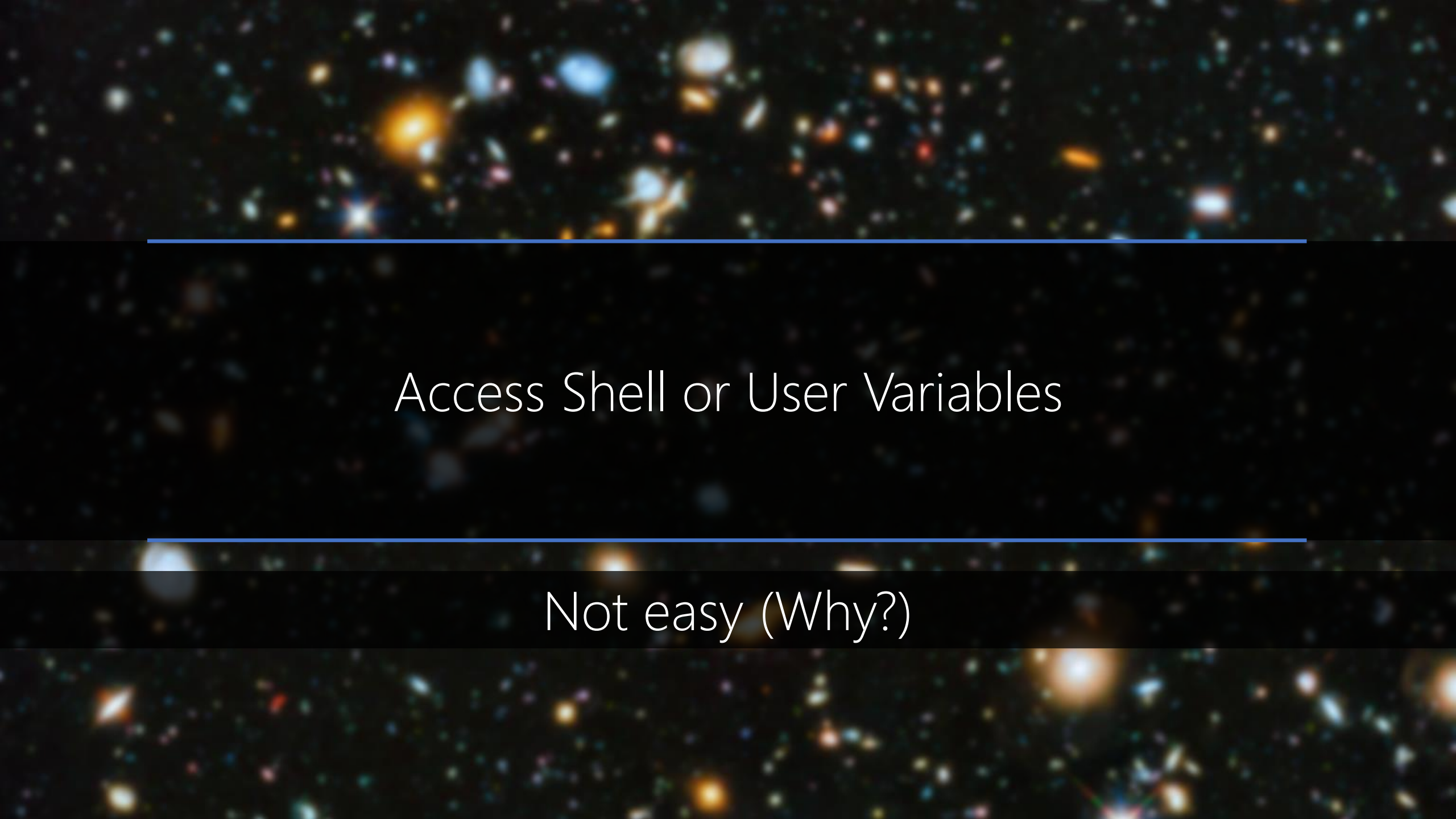


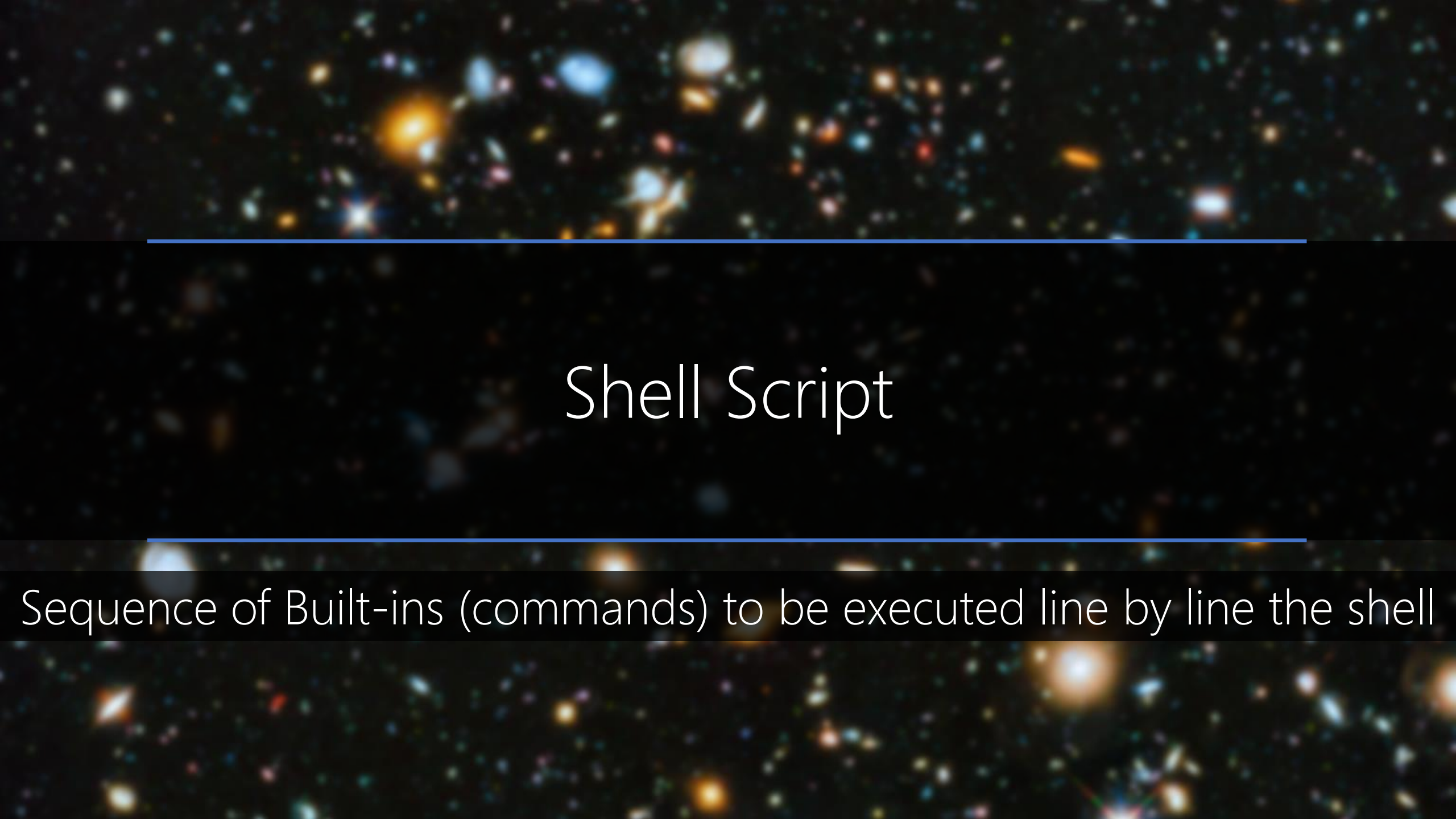

| Header | FreeBSD 8.0 | Linux 3.2.0 | Mac OS X 10.6.8 | Solaris 10 | Description |
|---|---|---|---|---|---|
| <aio.h> | • | • | • | • | asynchronous I/O |
| <cpio.h> | • | • | • | • | cpio archive values |
| <dirent.h> | • | • | • | • | directory entries (Section 4.22) |
| <dlfcn.h> | • | • | • | • | dynamic linking |
| <fcntl.h> | • | • | • | • | file control (Section 3.14) |
| <fnmatch.h> | • | • | • | • | filename-matching types |
| <glob.h> | • | • | • | • | pathname pattern-matching and generation |
| <grp.h> | • | • | • | • | group file (Section 6.4) |
| <iconv.h> | • | • | • | • | codeset conversion utility |
| <langinfo.h> | • | • | • | • | language information constants |
| <monetary.h> | • | • | • | • | monetary types and functions |
| <netdb.h> | • | • | • | • | network database operations |
| <nl_types.h> | • | • | • | • | message catalogs |
| <poll.h> | • | • | • | • | poll function (Section 14.4.2) |
| <pthread.h> | • | • | • | • | threads (Chapters 11 and 12) |
| <pwd.h> | • | • | • | • | password file (Section 6.2) |
| <regex.h> | • | • | • | • | regular expressions |
| <sched.h> | • | • | • | • | execution scheduling |
| <semaphore.h> | • | • | • | • | semaphores |
| <strings.h> | • | • | • | • | string operations |
| <tar.h> | • | • | • | • | tar archive values |
| <termios.h> | • | • | • | • | terminal I/O (Chapter 18) |
| <unistd.h> | • | • | • | • | symbolic constants |
| <wordexp.h> | • | • | • | • | word-expansion definitions |
| <arpa/inet.h> | • | • | • | • | Internet definitions (Chapter 16) |
| <net/if.h> | • | • | • | • | socket local interfaces (Chapter 16) |
| <netinet/in.h> | • | • | • | • | Internet address family (Section 16.3) |
| <netinet/tcp.h> | • | • | • | • | Transmission Control Protocol definitions |
| <sys/mman.h> | • | • | • | • | memory management declarations |
| <sys/select.h> | • | • | • | • | select function (Section 14.4.1) |
| <sys/socket.h> | • | • | • | • | sockets interface (Chapter 16) |
| <sys/stat.h> | • | • | • | • | file status (Chapter 4) |
| <sys/statvfs.h> | • | • | • | • | file system information |
| <sys/times.h> | • | • | • | • | process times (Section 8.17) |
| <sys/types.h> | • | • | • | • | primitive system data types (Section 2.8) |
| <sys/un.h> | • | • | • | • | UNIX domain socket definitions (Section 17.2) |
| <sys/utsname.h> | • | • | • | • | system name (Section 6.9) |
| <sys/wait.h> | • | • | • | • | process control (Section 8.6) |

```c
#include <stdio.h>
#include <unistd.h>

extern char **environ;
int main(int argc, char *argv[])
{
    int index = 0;
    printf("Environment variables:\n");
    index = 0;
    while (environ[index])
    {
        printf("envp[%d]: %s\n", index, environ[index]);
        ++index;
    }
    return 0;
}
```

*System call to Kernel!*
*Either statically or dynamically linked.*

```
Environment variables:
envp[0]: SHELL=/bin/bash
envp[1]: LANGUAGE=en_CA:en
envp[2]: NO_AT_BRIDGE=1
envp[3]: TWO_TASK=cs01
envp[4]: PWD=/home/hfani
envp[5]: LOGNAME=hfani
envp[6]: XDG_SESSION_TYPE=tty
envp[7]: PRINTER=cs_commons
envp[8]: MOTD_SHOWN=pam
envp[9]: VIRTUALENVWRAPPER_SCRIPT=/usr/share/virtualenvwrapper/virtualenvwrapper.sh
envp[10]: HOME=/home/hfani
envp[11]: LANG=en_CA.UTF-8
envp[12]: LS_COLORS=rs=0:di=01;34:ln=01;36:mh=00:pi=40;33:so=01;35:do=01;35:bd=40;33;01:cd=40;33;01:or=40;31;01:mi=00:su=37;41:
:ca=30;41:tw=30;42:ow=34;42:st=37;44:ex=01;32:*.tar=01;31:*.tgz=01;31:*.arc=01;31:*.arj=01;31:*.taz=01;31:*.lha=01;31:*.lz4=01;
=01;31:*.lzma=01;31:*.tlz=01;31:*.txz=01;31:*.tzo=01;31:*.t7z=01;31:*.zip=01;31:*.z=01;31:*.dz=01;31:*.gz=01;31:*.lrz=01;31:*.l
*.lzo=01;31:*.xz=01;31:*.zst=01;31:*.tzst=01;31:*.bz2=01;31:*.bz=01;31:*.tbz=01;31:*.tbz2=01;31:*.tz=01;31:*.deb=01;31:*.rpm=01
r=01;31:*.war=01;31:*.ear=01;31:*.sar=01;31:*.rar=01;31:*.alz=01;31:*.ace=01;31:*.zoo=01;31:*.cpio=01;31:*.7z=01;31:*.rz=01;31:
;31:*.wim=01;31:*.swm=01;31:*.dwm=01;31:*.esd=01;31:*.jpg=01;35:*.jpeg=01;35:*.mjpg=01;35:*.mjpeg=01;35:*.gif=01;35:*.bmp=01;35
1;35:*.pgm=01;35:*.ppm=01;35:*.tga=01;35:*.xbm=01;35:*.xpm=01;35:*.tif=01;35:*.tiff=01;35:*.png=01;35:*.svg=01;35:*.svgz=01;35:
;35:*.pcx=01;35:*.mov=01;35:*.mpg=01;35:*.mpeg=01;35:*.m2v=01;35:*.mkv=01;35:*.webm=01;35:*.webp=01;35:*.ogm=01;35:*.mp4=01;35:
;35:*.mp4v=01;35:*.vob=01;35:*.qt=01;35:*.nuv=01;35:*.wmv=01;35:*.asf=01;35:*.rm=01;35:*.rmvb=01;35:*.flc=01;35:*.avi=01;35:*.f
:*.flv=01;35:*.gl=01;35:*.dl=01;35:*.xcf=01;35:*.xwd=01;35:*.yuv=01;35:*.cgm=01;35:*.emf=01;35:*.ogv=01;35:*.ogx=01;35:*.aac=00
=00;36:*.flac=00;36:*.m4a=00;36:*.mid=00;36:*.midi=00;36:*.mka=00;36:*.mp3=00;36:*.mpc=00;36:*.ogg=00;36:*.ra=00;36:*.wav=00;36
0;36:*.opus=00;36:*.spx=00;36:*.xspf=00;36:
envp[13]: _VIRTUALENVWRAPPER_API= mkvirtualenv rmvirtualenv lsvirtualenv showvirtualenv workon add2virtualenv cdsitepackages cd
nv lssitepackages toggleglobalsitepackages cpvirtualenv setvirtualenvproject mkproject cdproject mktmpenv wipeenv allvirtualenv
alenv rmvirtualenv lsvirtualenv showvirtualenv workon add2virtualenv cdsitepackages cdvirtualenv lssitepackages toggleglobalsit
s cpvirtualenv setvirtualenvproject mkproject cdproject mktmpenv wipeenv allvirtualenv
envp[14]: ORACLE_HOME=/usr/lib/oracle/12.1/client64
envp[15]: SSH_CONNECTION=137.207.140.134 63217 137.207.82.51 22
envp[16]: WINEDLLOVERRIDES=winemenubuilder.exe=d
envp[17]: LESSCLOSE=/usr/bin/lesspipe %s %s
envp[18]: XDG_SESSION_CLASS=user
envp[19]: TERM=xterm
envp[20]: LESSOPEN=| /usr/bin/lesspipe %s
envp[21]: USER=hfani
```


Access Shell or User Variables
Not easy (Why?)



# Shell Script

Sequence of Built-ins (commands) to be executed line by line the shell

```
hfani@alpha:~$ vi myscript.sh
```

*By convention, the extension is .sh*

```
#!/bin/bash
```

*Important: under what shell?*

```
echo "hello world!"
echo "my name is $USER"
echo "here is the content of my home directory:"
ls ~/
~
~
~
~
~
~
~
~
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~
~
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~
~
~
~
~
~
~
~
~
```

```
hfani@alpha:~$ chmod +x myscript.sh
hfani@alpha:~$ ./myscript.sh
hello world!
my name is hfani
here is the content of my home directory:
Desktop    Downloads          hello    hellocat.txt  increment.o  ls.c    main.o
Documents  eclipse-workspace  hello.c  increment.c   increment.s  main.c  main.s
hfani@alpha:~$
```

*Important: make it executable*

# Shell Script

Lab03

```
hfani@alpha:~$ vi build_lab03.sh
```

```
#!/bin/bash
echo "start building lab03 program:"
echo "compiling to assembly lines ..."
cc main.c -S
cc increment.c -S
echo "translating to opcodes ..."
cc main.s -c
cc increment.s -c
echo "statically linking all required opcodes ..."
cc main.o increment.o -o main
echo "build successfully done!"
~
~
~
~
~
~
~
~
~
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~
~
~
~
~
~
```
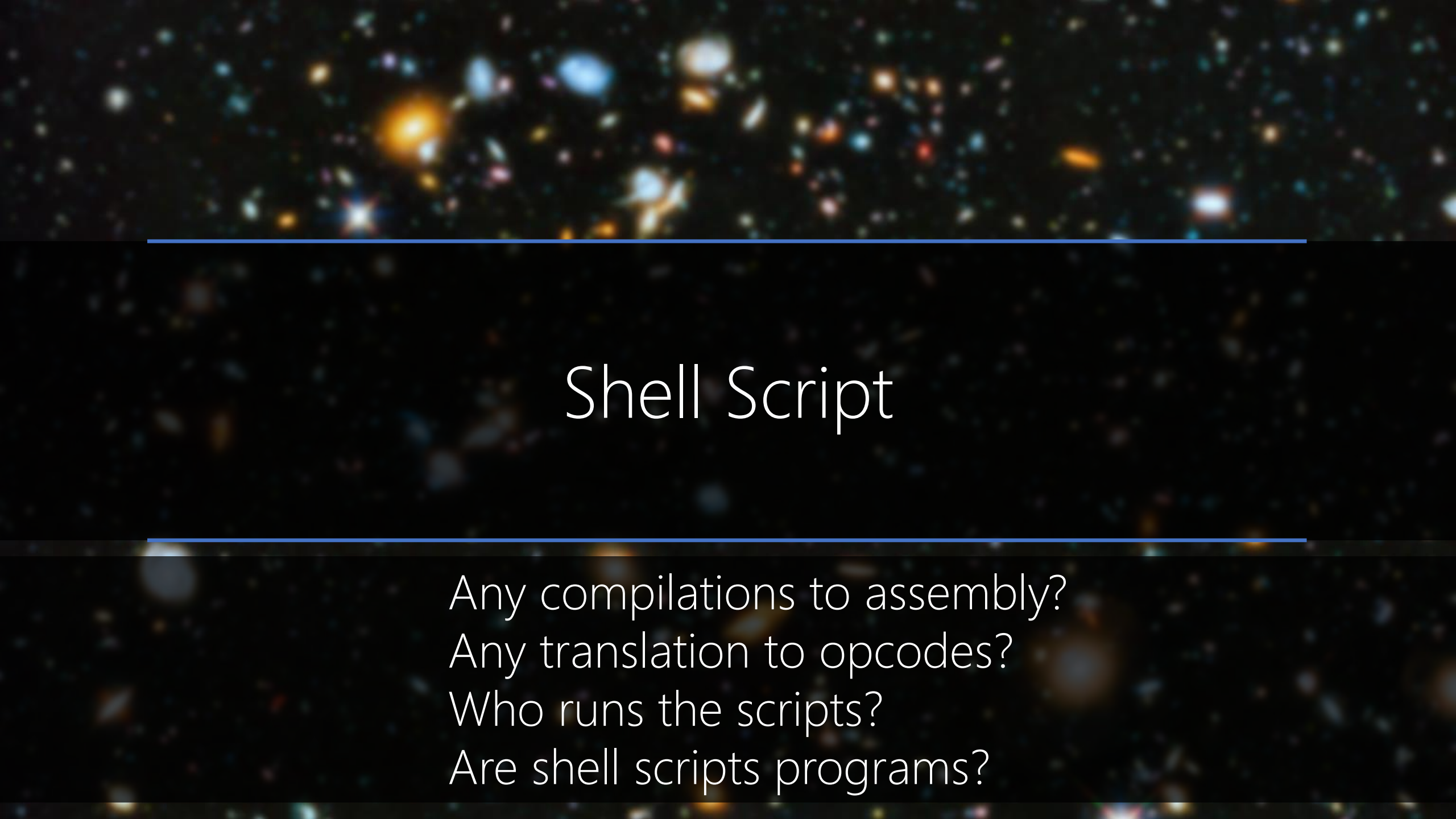
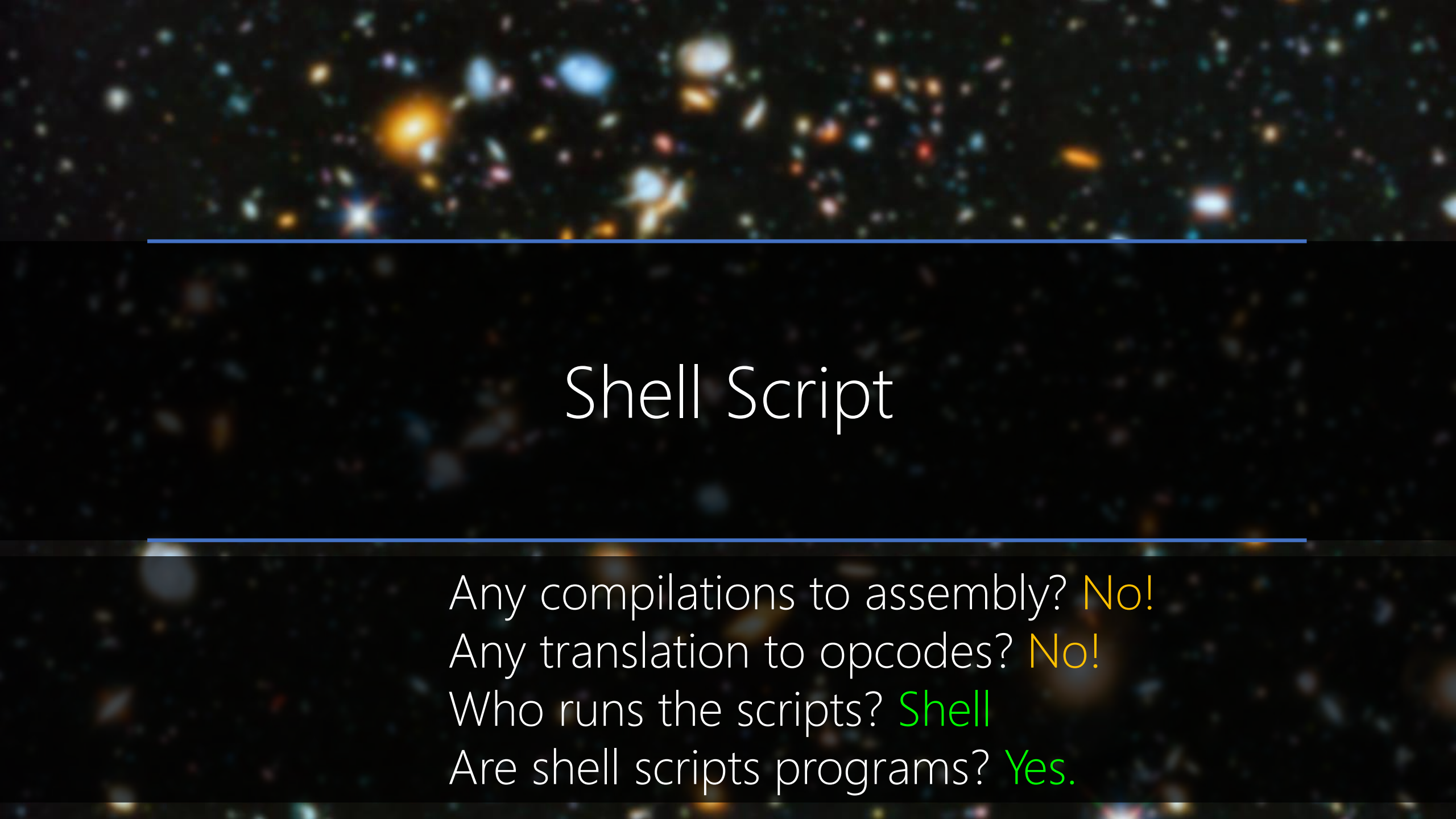

```
hfani@alpha:~$ chmod +x build_lab03.sh
hfani@alpha:~$ ./build_lab03.sh
start building lab03 program:
compiling to assembly lines ...
main.c: In function ‘main’:
main.c:5:6: warning: implicit declaration of function ‘increment’ [-Wimplicit-function-de
    5 |  a = increment(a);
      |      ^~~~~~~~~
translating to opcodes ...
statically linking all required opcodes ...
build successfully done!
hfani@alpha:~$
```



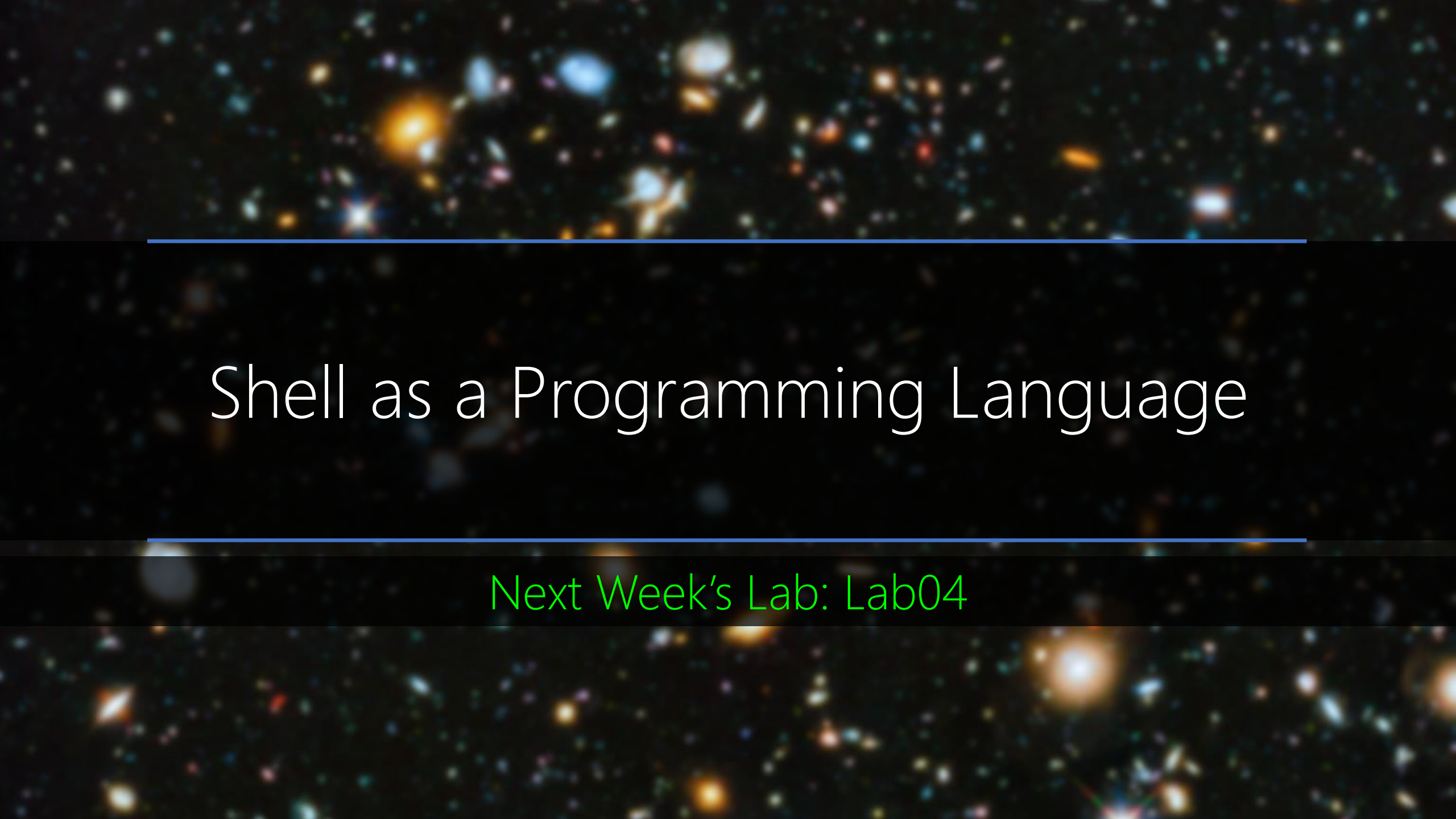
# Shell Script

Any compilations to assembly?
Any translation to opcodes?
Who runs the scripts?
Are shell scripts programs?



# Shell Script

Any compilations to assembly? No!
Any translation to opcodes? No!
Who runs the scripts? Shell
Are shell scripts programs? Yes.



# Shell as a Programming Language

Next Week's Lab: Lab04