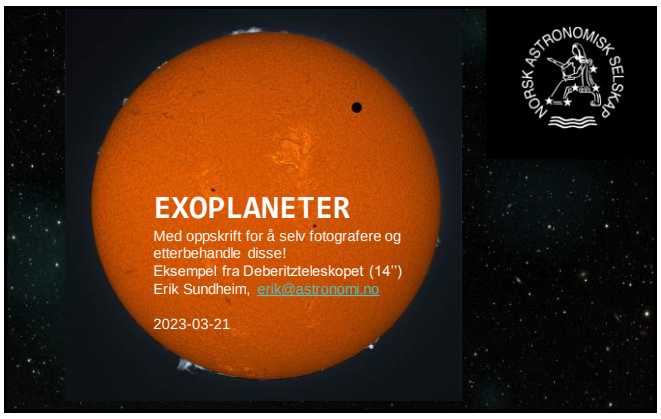

EXOPLANETER
Med oppskrift for å selv fotografere og etterbehandle disse!
Eksempel fra Deberitzteleskopet (14'')
Erik Sundheim, erik@astronomi.no
2023-03-21

1


Erik Sundheim
Amatørastronom
siv.ing. geodesi/landmåling
Leder av Norsk Astronomisk Selskap
erik@astronomi.no
https://www.astronomi.no/wiki/ (astrofoto-wiki)

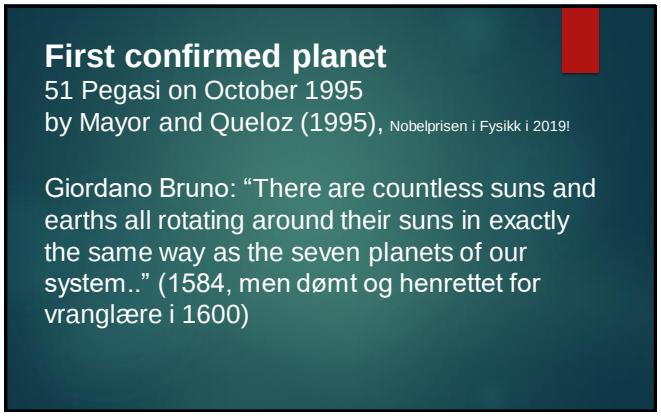
2


Exoplaneter ☺
I tillegg til å snakke om exoplaneter vil jeg vise hvordan vi fotograferer dem og prosesserer data ganske «enkelt» og lage lyskurver
Noe av det beste med exoplaneter:
• her er det lett å gjøre et bidrag til vitenskapen med å bekrefte at en exoplanet eksisterer (oppdager+2 andre teleskop)
• kan bestemme størrelsen på stjerna
• kan bestemme størrelsen på exoplaneten
• kan dele observasjoner
• Kanskje snart oppdager vi liv utenfor vårt solsystem!

3


Astronomi
REKORDMANGE EKSOPLANETER
Hva vi har funnet og veien videre
Ofte stilte spørsmål om
BIG BANG
GJENNOMGANG:
Kompakte teleskoper

4


First confirmed planet
51 Pegasi on October 1995
by Mayor and Queloz (1995), Nobelprisen i Fysikk i 2019!
Giordano Bruno: "There are countless suns and earths all rotating around their suns in exactly the same way as the seven planets of our system.." (1584, men dømt og henrettet for vranglære i 1600)

5


Hva er Exoplaneter?
• Planetlignende objekt som går i bane rundt andre stjerner enn sola.
• Exo means "outside" because these planets are outside our solar system.

6

2019-09-01:	2023-03-14:
4109 confirmed exoplanets	5336
3059 systems	3934
667 systems >> one planet	856
+10000 kandidater	

http://exoplanet.eu/catalog/

7

Size

- Its size can range from bigger from the planet Uranus (diameter- 51,118km or 4 times the size of Earth)
- They also can have the same mass as Earth.

8

Color

- Exoplanets are any color because there is a variety of different planets which have different colors.
- Example- Scientists have found a deep cobalt blue exoplanet.

9

How long is a day and year?

- Each exoplanet has a different relation with it's star.
- Over half of the exoplanets revolution takes less than 50 days to orbit around their star.
- 20% of exoplanets take less than 4 days to go around their star.
- Exoplanets are so far away that scientists can't see the rotation of them.

10

Density

- Depends on the mass and volume of the planet
- An example is the planet Kepler-78B is 20% larger than Earth and 70% more massive, but it's density is similar, indicating that Kepler-78B is composed of iron and rock

11

Gravity

- Exoplanets gravity is between 1-3 times the size of the surface gravity of Earth.
- The more the mass of the planet the more gravitational pull there is.

12

Atmosphere Composition

- Passasjemetoden gir mulighet til å studere atmosfæren ved å se på lysspekter (CO_2++ fra 2001)
- The close proximity of the gaseous planets to their star indicates that their atmospheres will have a much more intense heating and raised to extremely hot temperatures.

13

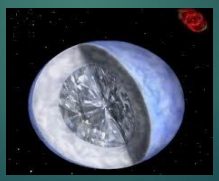
Surface Composition

- Larger exoplanets have been found to be gaseous
- Smaller planets have been found to have rocky terrain
- There is the nebular theory where the inner planets are rocky and the outer planets are mostly gaseous

14

Interior Composition

- Scientists predict that exoplanets are mainly made of Hydrogen and Helium Gas.



15

Magnetic Fields

- The magnetic fields depends on the core of the planet.

16

Moons

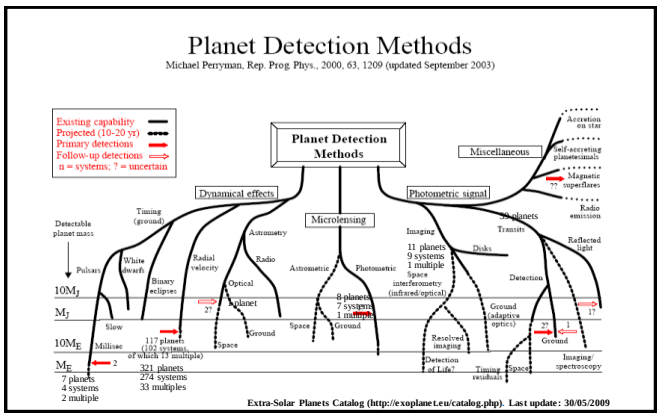
- Scientist hypothesize that exoplanet moons or exomoons would most likey be like Jupiter and Saturn's moons.
- In December 2013 a candidate exomoon of a rogue planet was announced. On 3 October 2018, evidence suggesting a large exomoon orbiting Kepler-1625b was reported.

17

Extra Extra Facts

- Exoplanets are named according to the observer who found them.
- They first discovered exoplanets in 1995
- At the last count there were 5300 exoplanets.
- The study of exoplanets is still developing.
- "Hot Jupiter's" are the gaseous planets that are close orbiting to their stars causing them to be hot.

18



19

How to detect exoplanets?

Discovery Method	2018	#Planets 2023
Transit	3009	3970
Radial Velocity	7005	1029
Microlensing	72	176
Imaging	44	63
Transit timing variations	15	24
Eclipse timing variations	9	17
Orbital brightness modulations	6	9
Pulsar timing variations	6	7
Astrometry	1	2
Pulsation timing variations	2	2
Disk Kinematics		1

https://exoplanetarchive.ipac.caltech.edu/docs/counts_detail.html

20

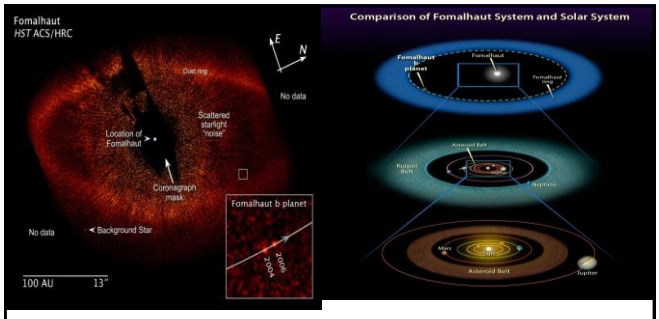
Methods for detection of Exoplanets

1) *Astrometry*: changing on spatial star position ➔ exoplanet detection - Inconclusive and marginal.

2) *Direct* (imaging) detection:
Direkte avbilding
only for BIG and sufficiently distant planets: weak contrast

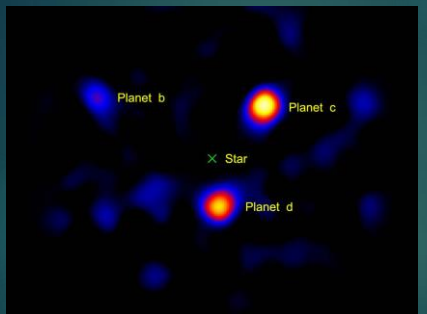
Contrast Star-Planet:
> 100,000,000 for a Jupiter-like planet in the Visible
~ 100,000 for a Jupiter-like planet in the IR
➔ interferometric/coronagraphic techniques

21



Direct detection: planet around star **Fomalhaut** (25 l-y from the Sun) 2008-11-13

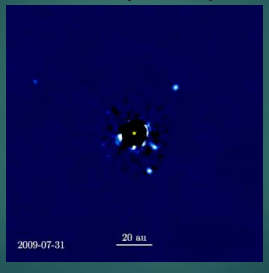
22



The three known planets of the star HR8799, as imaged by the Hale Telescope. The light from the central star was blanked out by a vector vortex coronagraph.

23

Four exoplanets orbiting counterclockwise with their host star (HR 8799)

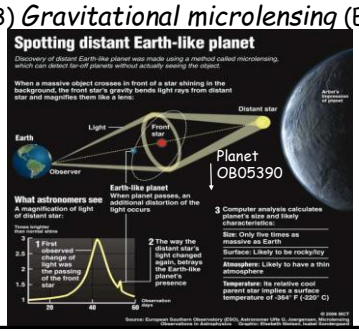


24

Methods for the detection of exoplanets

Mikrolinseeffekten

3) *Gravitational microlensing* (Einstein effect)



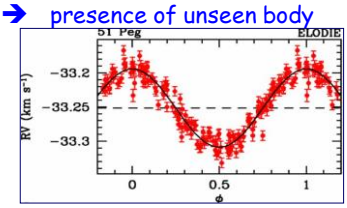
Some dozens exoplanets discovered with this method (Mpl ~Atm)

25

Methods for the detection of exoplanets
Radialhastighetsmetoden (51 Pegasi)

4) *Velocitometry*: stellar radial velocity variations ➔

➔ presence of unseen body



Many hundred exoplanets discovered by this method

Radial velocity variations + Kepler's 3rd law ➔ Mpl ; Porb

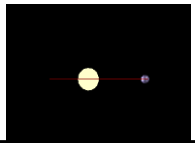
26

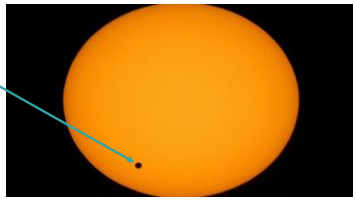
Methods for the detection of exoplanets
Passasjemetoden

5) Transit method: detection of the tiny eclipse caused by the passage (transit) of a planet in front of its star.

➔ R_{pl} ; P_{orb}

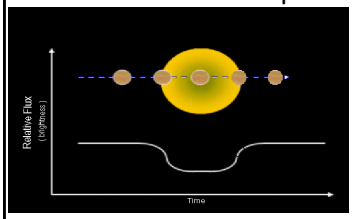
Transit of VENUS
June 6, 2012

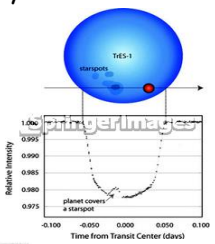


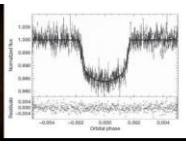


27

Method of planetary *Transits*







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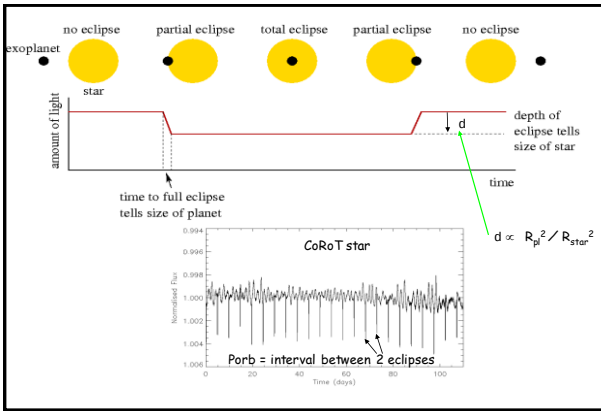


29

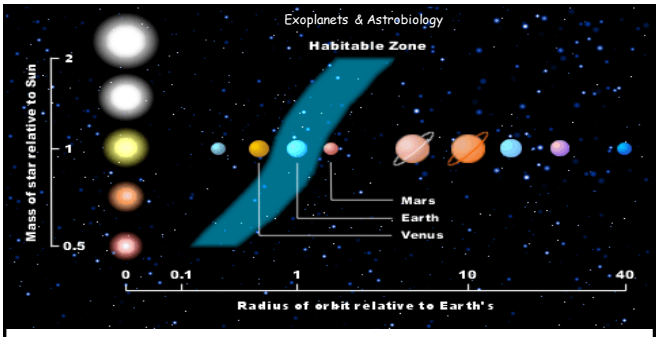
The Habitable Zone (HZ)

Definition: region around a star where the temperature on the surface of an eventual planet or moon can afford the presence of liquid water.

Conditions: the position and width of the HZ depends on the presence and composition of the atmosphere (greenhouse effect - GE).

On **EARTH**: GE raises temperature by ~32 °C

30



The Habitable Zone (HZ): liquid water
Utvides stadig (ref. Pluto)!

31

Prospects for finding habitable planets

- Best candidates are F, G, and early K-type stars, *i.e.*, stars not too different from the Sun
- Early-type stars (blue stars)
  - High UV fluxes
  - Short main sequence lifetimes
- Late-type stars (red dwarfs) – M-class
  - Tidal locking
  - Lots of flares

32

Planets and Astrobiology

Most favorable cases: **F-G-K stars** (similar to the Sun): stability and evolution time

Hot (blue) stars: too much **UV radiation** and short **MS** evolution time

Cold (red dwarf) stars: energetic explosions (**flares**) and **tidal lock** problem.
But: 85% of stars in Milky Way are red dwarfs (> 100 billion ≡ many planets)

33

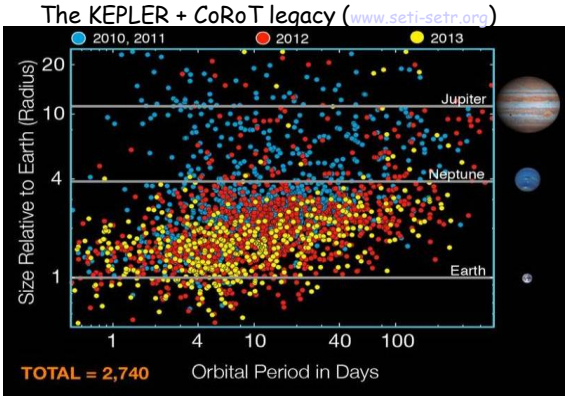
THE EXOPLANET ZOO

Number of planets in the Milky Way:
~ 400 billion

Number of **Earth-like** planets in the Milky Way: ~ 100 billion

34

The KEPLER + CoRoT legacy (www.seti-setr.org)



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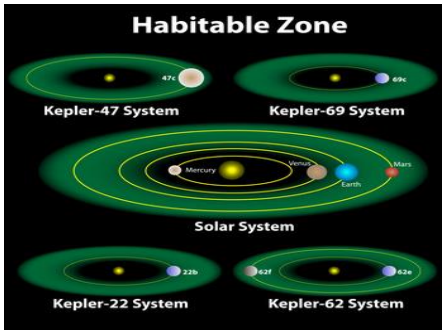


36

Exoplanet count by Radius:

Less than 1.25 Earth radius	388
Greater than 1.25 less than 2 Earth radii	825
Greater than 2 less than 6 Earth radii	1294
Greater than 6 less than 15 Earth radii	445
Greater than 15 Earth radii	141

37

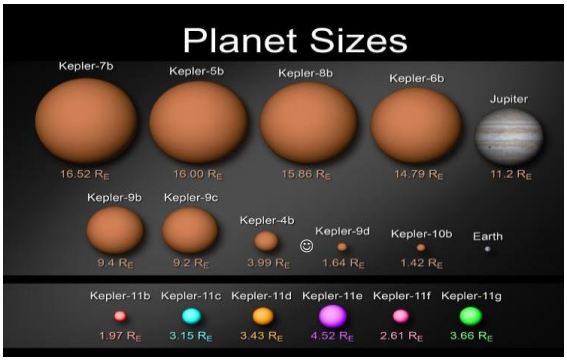
Kepler Mission Counts

Confirmed Planets discovered by Kepler	2328
Habitable Zone Confirmed and Candidates*	361
Kepler Project Candidates	4717
Kepler Project Candidates yet to be Confirmed	2425
Total Candidates and Confirmed Planets	4770

Kepler 2 Mission Counts (08/31/2017)

Confirmed Planets Discovered by K2	359
K2 Candidates yet to be Confirmed	473
K2 Campaign 9 Microslensing Events	627

38



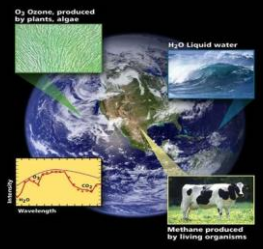
☺ = CoRoT7b

39

How Will We Know A Planet Supports Life?

Look for evidence of oxygen

Look for liquid water

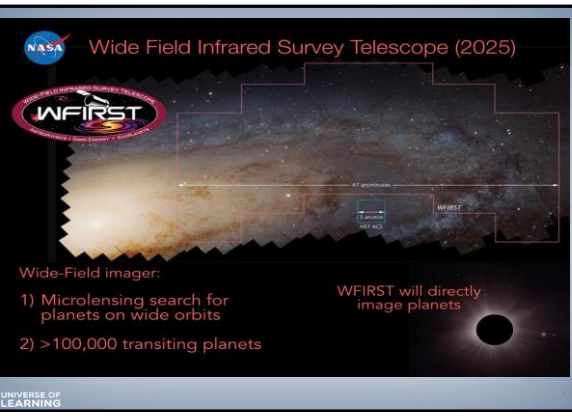


Analyze the reflected light from the planet to see if the planet has an atmosphere

Look for signs of biological activity (methane)

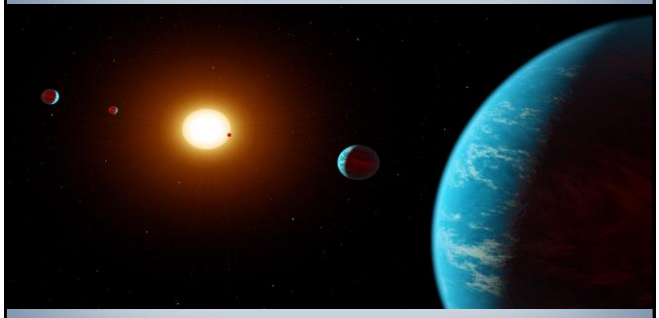
And Rule Out Other Explanations?

40



41

K2-138, the first multi-planet system found entirely by citizen scientists

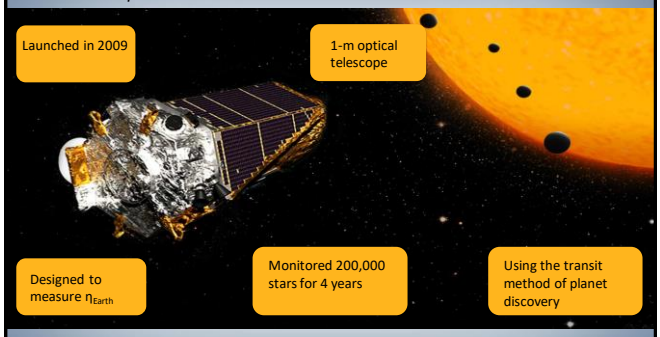


And 94 more planet candidates identified in the last MONTH!

UNIVERSE OF LEARNING

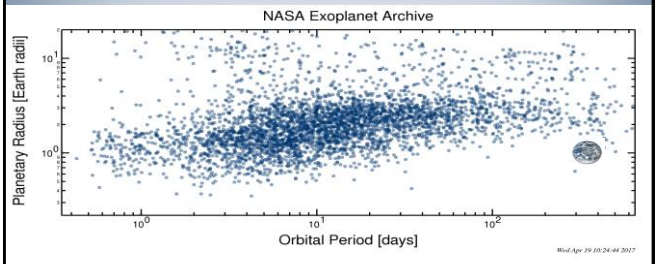
42

The NASA Kepler Mission



43

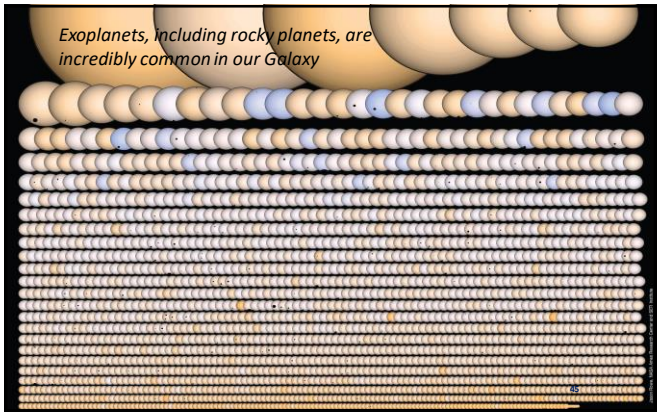
The final Kepler planet candidate catalog



Thompson et al., submitted

UNIVERSE OF LEARNING

44



45

Future missions await …

46

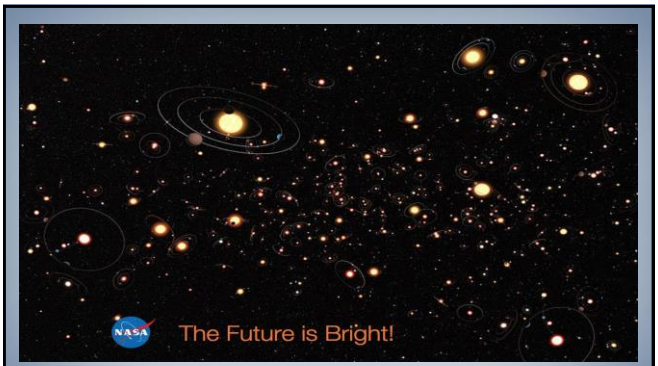
NASA's Kepler/K2 Missions

- Kepler telescope launched in 2009 to search for exoplanets in a single field of view
- Spacecraft re-purposed as K2 in 2014 to continue observations along the ecliptic plane

NASA Ames/W. Stenzel

UNIVERSE OF LEARNING

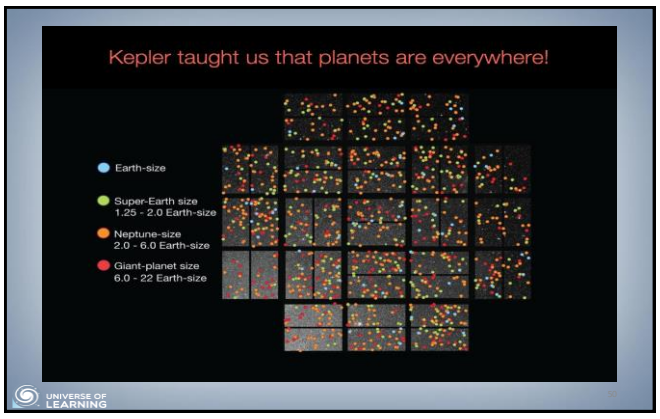
47



UNIVERSE OF LEARNING

48

49



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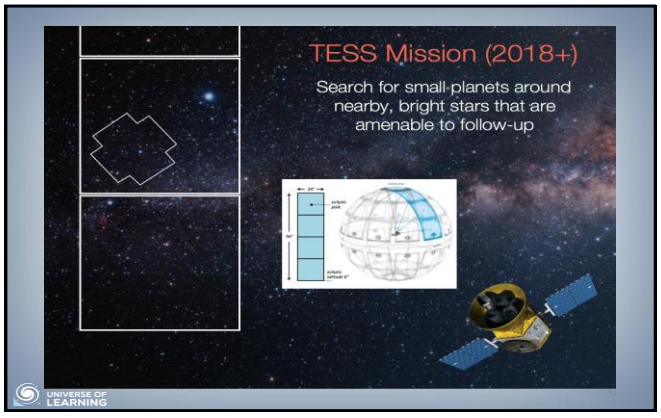

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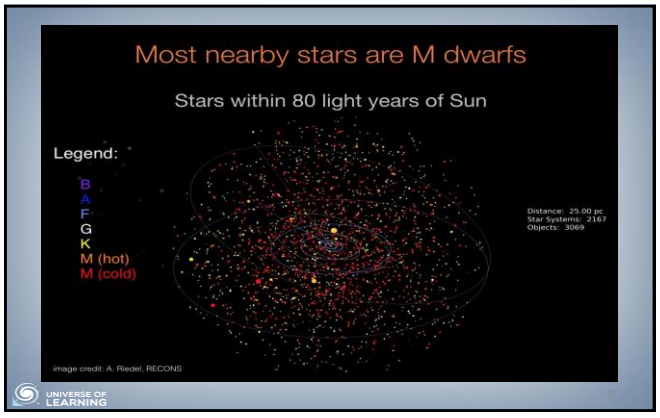

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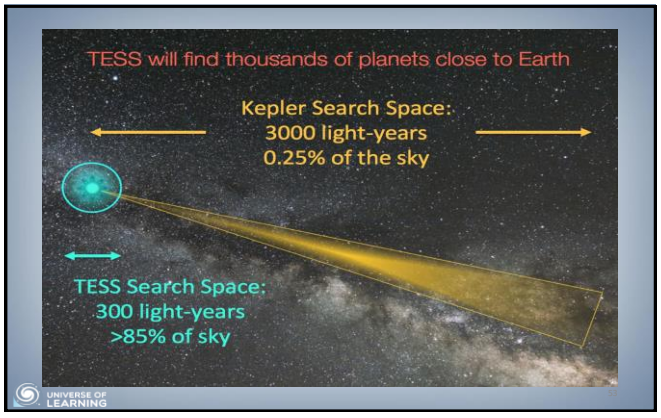

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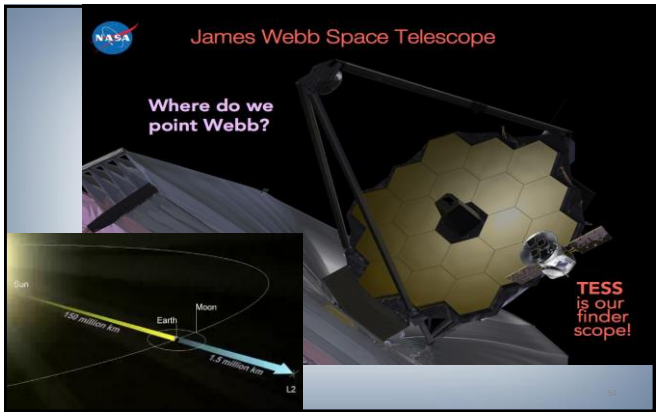
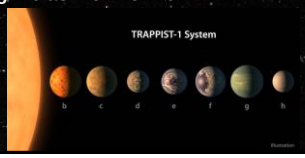


54

JWST (2021-12-25, 6,5m speil) fotograferer TRAPPIST-1 planeter! 39 l-y away

Scientists are particularly interested in the TRAPPIST-1 system because, although simulations in previous studies have shown that most of the worlds in this system are probably uninhabitable, one — TRAPPIST-1e — could host liquid water and be capable of supporting life as we know it.



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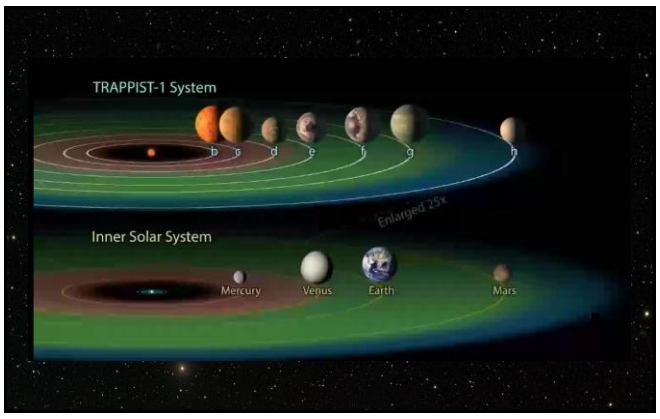
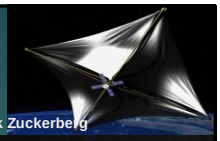
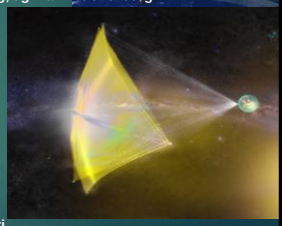


56

Besøke eksoplaneter!





Breakthrough Starshot, romfartøy+lysseil StarChip

- Startet i 2016 av Yuri Milner, Stephen Hawking, og Mark Zuckerberg
- Hastighet 15-20% av lyshastighet
- Vil bruke 20-30 år ut
- Ca 4 år for retur signal tilbake
- Array (km) laser power 100 GW
- Kostnad 5–10 mrd us$
- Sendes opp 2036

- Fly ut til Exoplanet Proxima Centauri b
- Oppdaget i August 2016
- European Southern Observatory (ESO)
- Avstand 4,37 lysår
- Jordstørrelse exoplanet
- Beboelig sone rundt stjerna Proxima Centauri
- Proxima Centauri, 3. Stjerne i Alpha Centauri systemet

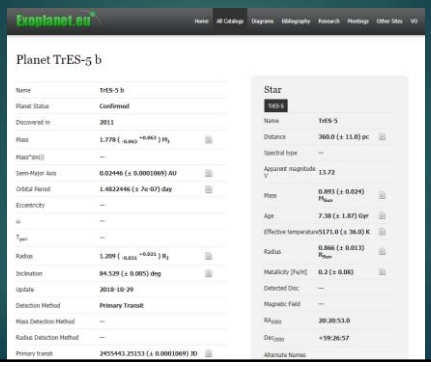
57

Local evening date	Name	V or Kepler mag	Start—Mid—End	Duration	BJD_{TDB} start-mid-end	Elev. at start, mid, end ±1.9 hrs
Fri. 2019-09-27 Nautical twilight 20:33 – 05:43 (CET)	TrES-5 b Finding charts: Annotated, SkyMap; Info: Exoplanets.org, Simbad, Gaia DR2, TIC, VSX, Vizier phot., Airmass plot, ACP plan	13.72 Moon 1% @103°	01:14 03:08—04:03—04:59 06:53 ±0:02	1:51	8754.547 8754.586 8754.625	61° 49°, 44°, 39° 33°

% of transit (baseline) observable, Suggested obs. start, end	Az. at start, mid, end ±1.9 hrs	HA at start, mid, end ±1.9 hrs	RA & Dec (J2000)	Period (days)	Depth (ppt)
100% (69%) 01:12—05:43	296° 310°, 317°, 324° 340°	+4.0 +5.9, +6.9, +7.8 +9.7	20:20:53.25 +59:28:55.6	1.48	20.6

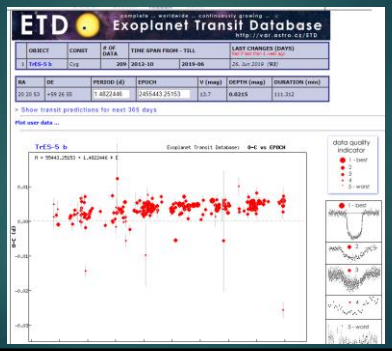
58

http://exoplanet.eu/catalog/tres-5_b/



59

http://var2.astro.cz/ETD/etd.php?STARNAME=TrES-5&PLANET=b



60

You need at least the following:

- Celestial coordinates of the star (RA, Dec.)
- Orbital period of the planet
- Radius of the star (in solar units)
- Effective surface temperature of the star
- V-band magnitude of the star
- Predicted ingress, mid-point and egress of the transit
- Limb darkening parameters see:
  http://astroutils.astronomy.ohio-state.edu/exofast/limbdark.shtml

NOTE: For the purpose of finding predicted times, use the Exoplanet Transit Database rather than the Swarthmore site, as the former tends to be more accurate!

(**Exoplanet Transit Database** URL for Solobservatioriet LAT/LON for i natt):

http://var2.astro.cz/ETD/predictions.php?delka=10.7516666667&submit=submit&sirka=60.2119444444

61

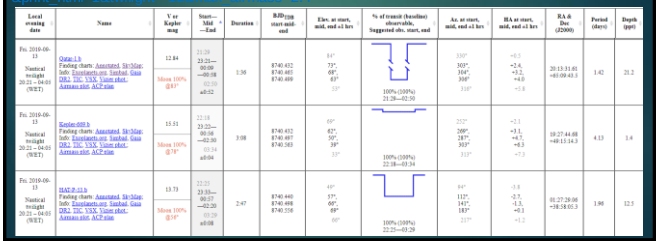
Oppskrift:

a) Collect the necessary calibration frames (bias, dark, plus flat-field frames for the relevant filter)
b) Calibrate telescope pointing (during twilight, if weather allows)
c) Go to the target and (if necessary) focus the telescope
d) Start the autoguider
e) Collect a time series of exposures covering an exoplanet transit, ideally including *at least 30 minutes* of out-of-transit observations before and after the event

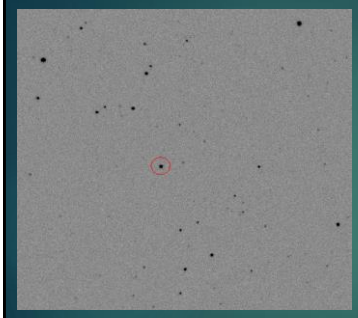
Elevation >30 gr
30/60/90/120sek. eksponering

62

(URL for Solobservatioriet LAT/LON neste 2 dager fra 2019-09-13):
https://astro.swarthmore.edu/transits/print_transits.cgi?observatory_string=Specified_Lat_Long&use_utc=0&observatory_latitude=60.2119444444&observatory_longitude=10.7516666667&timezone=WET&start_date=09-13-2019&days_to_print=2&days_in_past=0&minimum_start_elevation=20&and_vs_or=or&minimum_end_elevation=20&minimum_ha=-12&maximum_ha=12&baseline_hrs=16&show_utc=1&minimum_depth=0&maximum_V_mag=&target_string=&single_object=0&int=1&tec=&epoch=4&period=&duration=&target=&show_ephemeris=0&print_html=1&twilight=-12&max_airmass=2.4



63



Stellar Properties

Star Name	Qatar-1
Other Name	J20133160+6509433
Mass of Star[msun]	0.850 ± 0.03
Radius of Star[rsun]	0.823 ± 0.025
Density of star[g/cm^3]	2.13 ± 0.168

Qatar-1b, Discovery and References

a hot Jupiter orbiting a metal-rich K dwarf star	
First Publication Date	2011
Method of discovery for the planet	Transit

Orbital Parameters

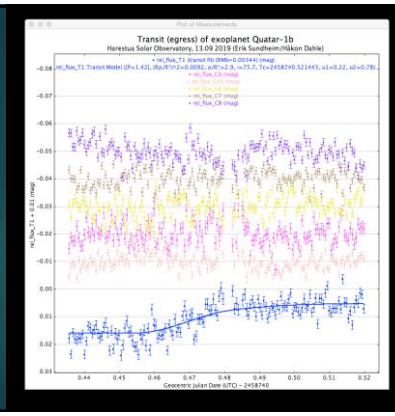
Msin(i)[mjupiter]	1.083 ± 0.085
Planet Mass[mjupiter]	1.090 ± 0.085
Separation[au]	0.02343 ± 0.00039
Orbital Period[day]	1.420033 ± 1.6×10-5

Stellar Magnitude

V mag 12.8

Vi fotograferte med Deberitsteleskopet 14" :
166x30sek, Filter: SDSS-i'
Near Infrared (i) Wavelength
7625 Angstroms, 762.5nanometer
11xBIAS
9xDARK 30s
12xFlat 0,3s
5xFlat 0,2s
5xFlat 0,4s

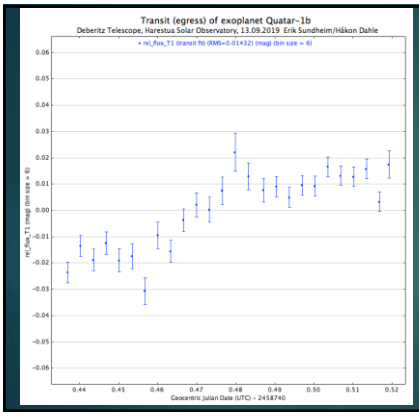
64



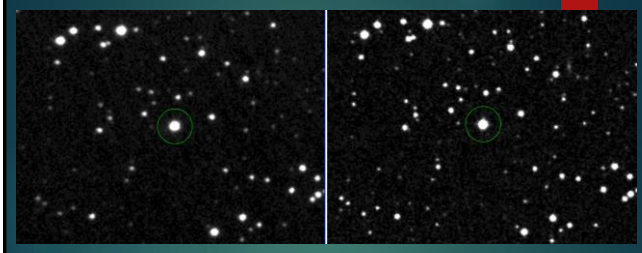
den blå heltrukne kurven er en modelltilpasning til dataene vi tok.

De andre målepunktene er lyskurver for sammenligningsstjernene jeg brukte i feltet

65



66



zoomet inn på stjerna i en kombinert 76-minutters eksponering sammensatt av alle enkelteksponeringene fra fredag og sammenlignet med data for det samme området fra Digitized Sky Survey (fotografiske plater fra 1.2-m Schmidt-telskopet) ved Palomar-observatoriet. De svakeste stjernene synlig i den kombinerte eksponeringen fra Deberitz-teleskopet er av magnitude omkring i=19.0. Og det var forresten fullmåne da vi observerte...

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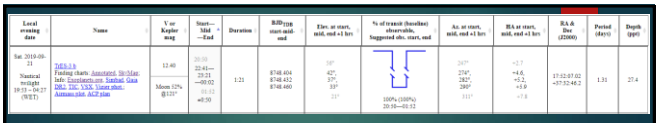
Qatar Exoplanet Survey is an extrasolar planets searching project for extrasolar planets by using the **transit method**. The above image is for the system that is located in New Mexico.
http://www.qatarexoplanet.org/

Lenses
4 Canon 400mm, f/2.8 & 1 200mm, f2

CCD Camera
5 FLI ProLine PL16801, KAF-16801E

Mount
Equatorial Fork type mount.
Paramount mount.

68



Star Name **TrES-3**
Other Name GSC 03089-00929
Mass of Star[msun] 0.915 +0.031/-0.021
Radius of Star[rsun] 0.812 +0.014/-0.025
Density of star[g/cm^3] 1.646 ± 0.047
V mag 12.4

TrES-3 b
Discovery and References
First Publication Date 2007
Method of discovery for the planet
Transit
Orbital Parameters
Msin(i)[mjupiter] 1.873 ± 0.084

(URL for Solobservatoriet LAT/LON neste 2 dager):
https://astro.swarthmore.edu/transits/print_transits.cgi?observatory_string=Specified_Lat_Long&use_my_observatory_latitude=60.2119444444&observatory_longitude=10.7516666667&timezone=CET&use_now_today&days_to_print=1&days_in_past=0&faintest_start_elevation=20&and_vs_or=or&minimum_end_elevation=20&minimum_ha=-12&maximum_ha=12&baseline_hrs=1.9&minimum_depth=5&maximum_V_mag=14&target_string=&single_object=0&ra=&dec=&epoch=&period=&duration=&target=&show_ephemeris=0&print_html=1&twilight=-12&max_airmass=2.4

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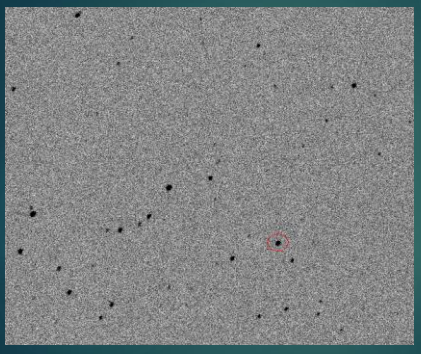
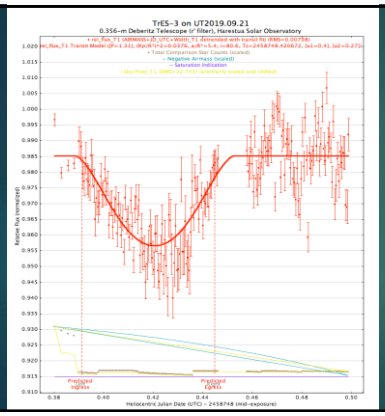


Vi fotograferte med Deberitsteleskopet 14" :
181x30sek,
Filter: SDSS-r' Red (r)
Wavelength
6231 Angstroms,
623.1 nanometer

11xBIAS
9xDARK 30s
11xFlat 0,3s
11xFlat 0,2s
7xFlat 0,1s

70



Planetradien blir overestimert med 17% ved tilpasning til dataene våre.

Det er ikke så galt :)

71

Flatfield/Domeflats:

0.2 og 0.3 sek. Eksponering på hvitt område funker fint!

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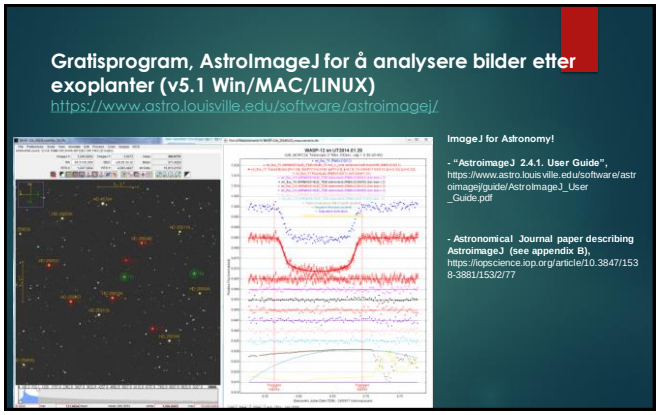
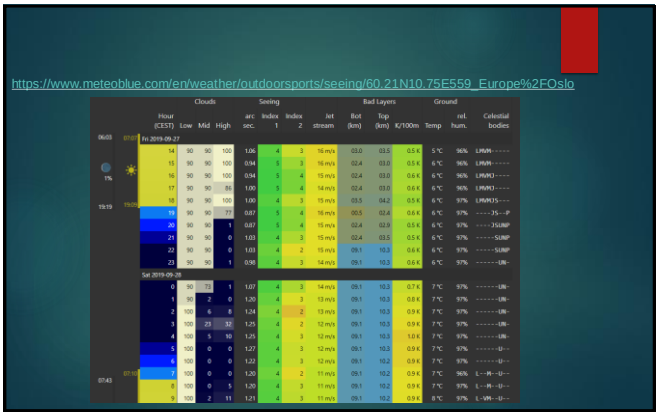
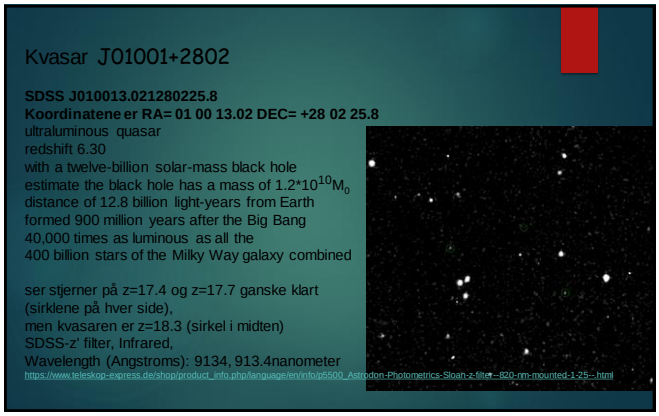


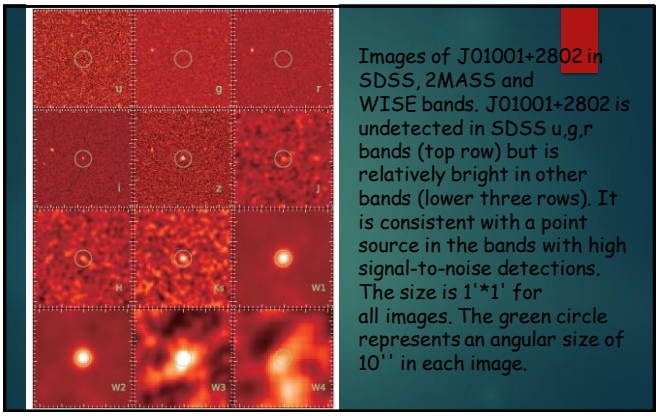
74



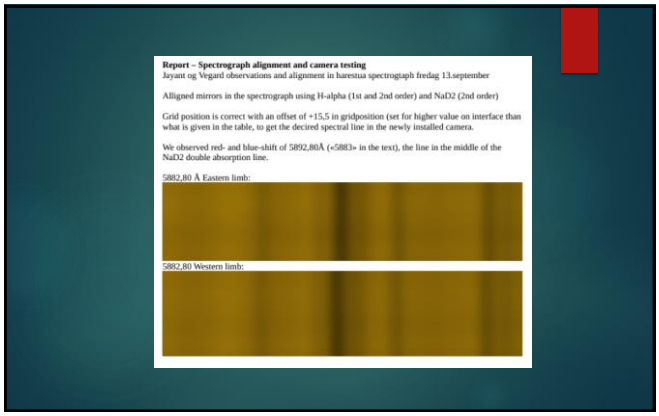
75



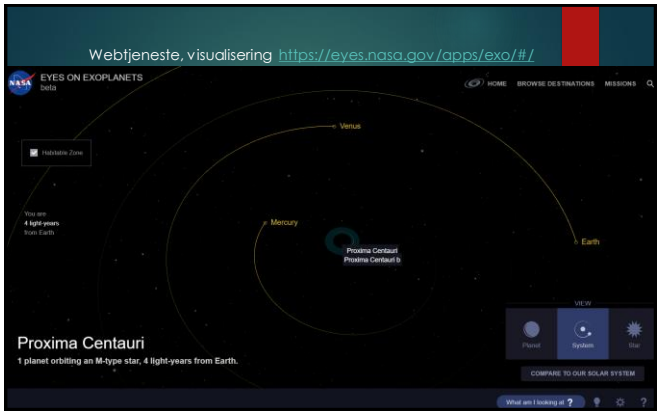
76



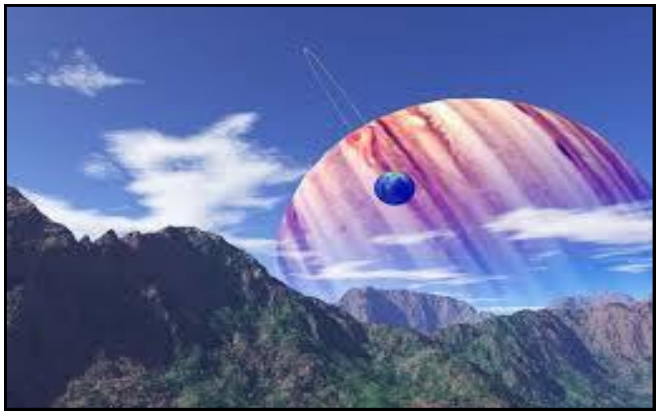
77



78



79



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Fotografering /etterbehandling, Viktige lenker!

AstroImageJ gratisprogrammet for å analysere bilder bl.a. etter exoplanter
https://www.astro.louisville.edu/software/astroimagej/
Eksempeldata som vi bruker idag:
https://www.astro.louisville.edu/software/astroimagej/examples/

"A practical guide to exoplanet observing"
https://astrodennis.com/Guide.pdf

SIMBAD online stjerneatlas (husk FOV)
http://simbad.cfa.harvard.edu/simbad/sim-basic

Use the exoplanet transit finder to locate suitable transits
https://astro.swarthmore.edu/transits
https://astro.swarthmore.edu/print_transits.cgi?observatory_string=Specified_Lat_Long&use_utc=0&observatory_latitude=60.2119444444&observatory_longitude=10.7516666667&timezone=CET&start_date=today&days_to_print=1&days_in_past=0&minimum_start_elevation=20&and_vs_or=or&minimum_end_elevation=20&minimum_ha=-12&maximum_ha=12&baseline_hrs=1.9&minimum_depth=5&maximum_V_mag=&target_string=&single_object=0&ra=&dec=&epoch=&period=&duration=&target=&show_ephemeris=0&print_html=1&twilight=-12&max_airmass=2.4

Extrasolar Planets Encyclopaedia:
http://exoplanet.eu/

Mer nøyaktige tider, Exoplanet Transit Database ETD:
http://var2.astro.cz/ETD/

Dele observasjoner:
https://app.aavso.org/exosite/submit

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Fotografering

1. **Bla gjennom https://astrodennis.com/Guide.pdf**
2. **Planlegg vha: https://astro.swarthmore.edu/transits**
3. **Bekreft tidene med http://var2.astro.cz/ETD/**
4. **Husk å starte minst en time før passering/transit, og fotografering minst 30min før og etter passering!**
5. **Prøv deg fram til en god eksponeringstid, pass på at målstjernen ikke blir «mettet/saturated», "ADU count << 75% of the saturation point" 30/60sek pleier å passe bra**
6. **Følg oppskriften på s.62 (og husk å ta 10-20stk av hver Dark, Bias, Flats)**

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Etterbehandling/prosessering

1. Start AstroImageJ
2. Bla gjennom guiden: https://astrodennis.com/Guide.pdf
3. File – Import – Image sequence 230filer går ganske raskt (fra SSD)
4. Se gjennom bildene (play)
5. Kalibrer med Darks/Flats/Bias

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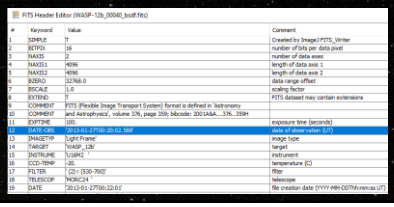
Sjekk og les FITS header:

Linje	Nøkkel	Verdi	Forklaring
12	DATE-OBS	'2013-01-27T00:20:02.588'	date of observation (UT)
77	SITELAT	38.344791666666666	geographic latitude of observatory
78	SITELONG	-85.528475	geographic longitude of observatory
18	teleskop	Moore Observatory Ritchie–Chretien (MORC) 0.6m	
15	kamera	Apogee U16M (Kodak KAF-16803 CCD)	



85

https://astro.swarthmore.edu/transits/print_transits.cgi?single_object=0&ra=&dec=&epoch=&period=&duration=&depth=&target=&observatory_string=Specified_Lat_Long&use_utc=1&observatory_latitude=38.344791666666666&observatory_longitude=-85.528475&timezone=UTC&start_date=01-27-2013&days_to_print=1&days_in_past=0&minimum_start_elevation=20&and_vs_or=or&minimum_end_elevation=20&minimum_ha=&maximum_ha=&baseline_hrs=1&show_unc=1&minimum_depth=0&maximum_V_mag=&target_string=&print_html=1&twilight=-12&max_airmass=2.4

Local evening date	Name	V or Gaia mag	Start—Mid—End	Duration	BJD_{TDB} start, mid, end	Elev. at start, mid, end ±1 hrs	% of transit (baseline) observable, Suggested obs. start, end	Az. at start, mid, end ±1 hrs	HA at start, mid, end ±1 hrs	RA & Dec (J2000)	Period (days)	Depth (ppt)	Comments
23:59 – 11:50 (UTC)	Info, Exoplanet Archive, Simbad, Gaia, TIC	99% @125°	06:43 ±1:40			-28°	3% (47%) 23:59—02:33	297°	+8.6				
Sun. 2013-01-27 (local date) Nautical twilight 23:59 – 11:50 (UTC)	WASP-12 b Finding charts: Annotated, Aladin, SkyView, Astrosa.plot, ACP plan Info: Exoplanet Archive, Simbad, Gaia, TIC	11.6 Moon 99% @47°	02:59 04:00—05:51 —07:02 08:02 ±0:00	3:02	6320.6719 6320.7353 6320.7986	77° 81°, 66°, 48° 37°	100% (100%) 02:59—08:02	130° 203°, 257°, 273° 281°	-0.7 +0.3, +1.8, +3.3 +4.3	06:30:32.79 +29:40:20.16	1.09	17.1	

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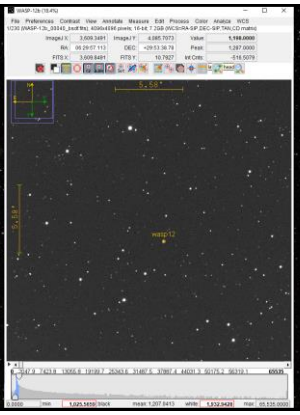
Høyremuseklikk for å gi en stjerne et navn (Annotate)

Dette vil laste Simbad



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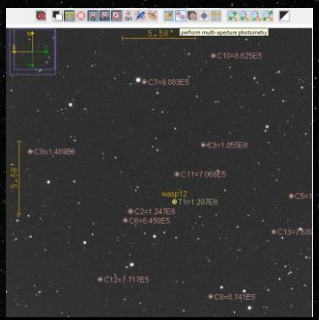
Slå opp i SIMBAD og finn stjerna (FOV)

http://simbad.cfa.harvard.edu/simbad/sim-basic?Ident=wasp-12&submit=SIMBAD+search

88

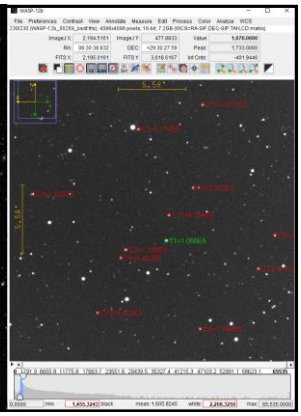
Perform multi-aperture photometry



89

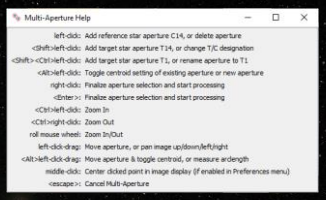
Klikk på hovedstjerna **(Target)**

Programmet velger automatisk referansestjerner



90

ENTER for å starte prosessering



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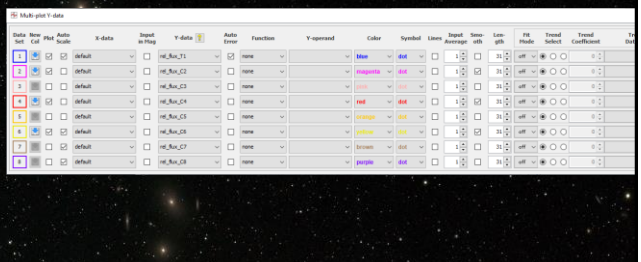
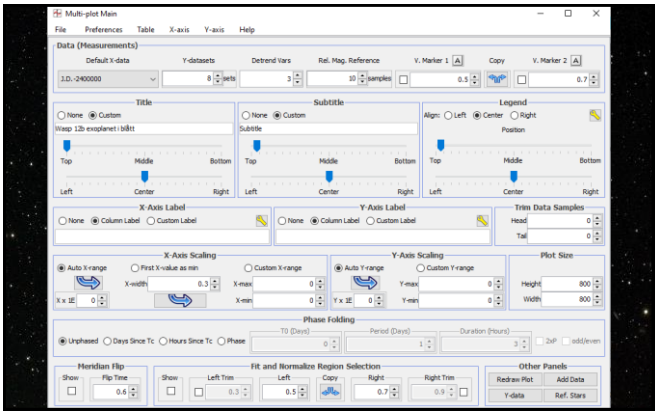
Lag et passende plott med noen referansestjerner



92



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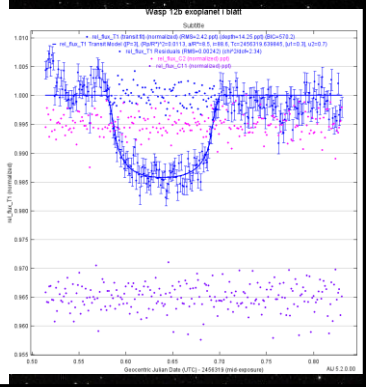
Info fra: https://exofop.ipac.caltech.edu/tess/target.php?id=wasp-12
Og: http://exoplanet.eu/catalog/wasp-12_b/
Og artikkel: https://iopscience.iop.org/article/10.3847/1538-3881/153/2/78/pdf

WASP-12 stjerna:
Double or Multiple Star
Type: G0
Magnitude: 11,69
Avstand: 1400 lysår
Radius(R_sun): 1.7x
Masse(M_sun): 1.4x
WASP-12 b eksoplaneten:
Oppdaget: 2008 (publisert 2017)
Type: hot-Jupiter
Periode: 1,09 jordag
Transit varighet: 3.04 t
Dybde (lysstyrkevariasjon): 1,7%
Radius(R_earth): 22x
Masse(M_Earth): 466x
Overflatetemp.: 2593°K



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Dele observasjoner:

https://app.aavso.org/exosite/submit

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Exoplaneter ☺

I tillegg til å snakke om exoplaneter vil jeg vise hvordan vi fotograferer dem og prosesserer data ganske «enkelt» og lage lyskurver

Noe av det beste med exoplaneter:

- her er det lett å gjøre et bidrag til vitenskapen med å bekrefte at en exoplanet eksisterer (oppdager+2 andre teleskop)
- kan bestemme størrelsen på stjerna
- kan bestemme størrelsen på exoplaneten
- kan dele observasjoner
- Kanskje snart oppdager vi liv utenfor vårt solsystem!

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