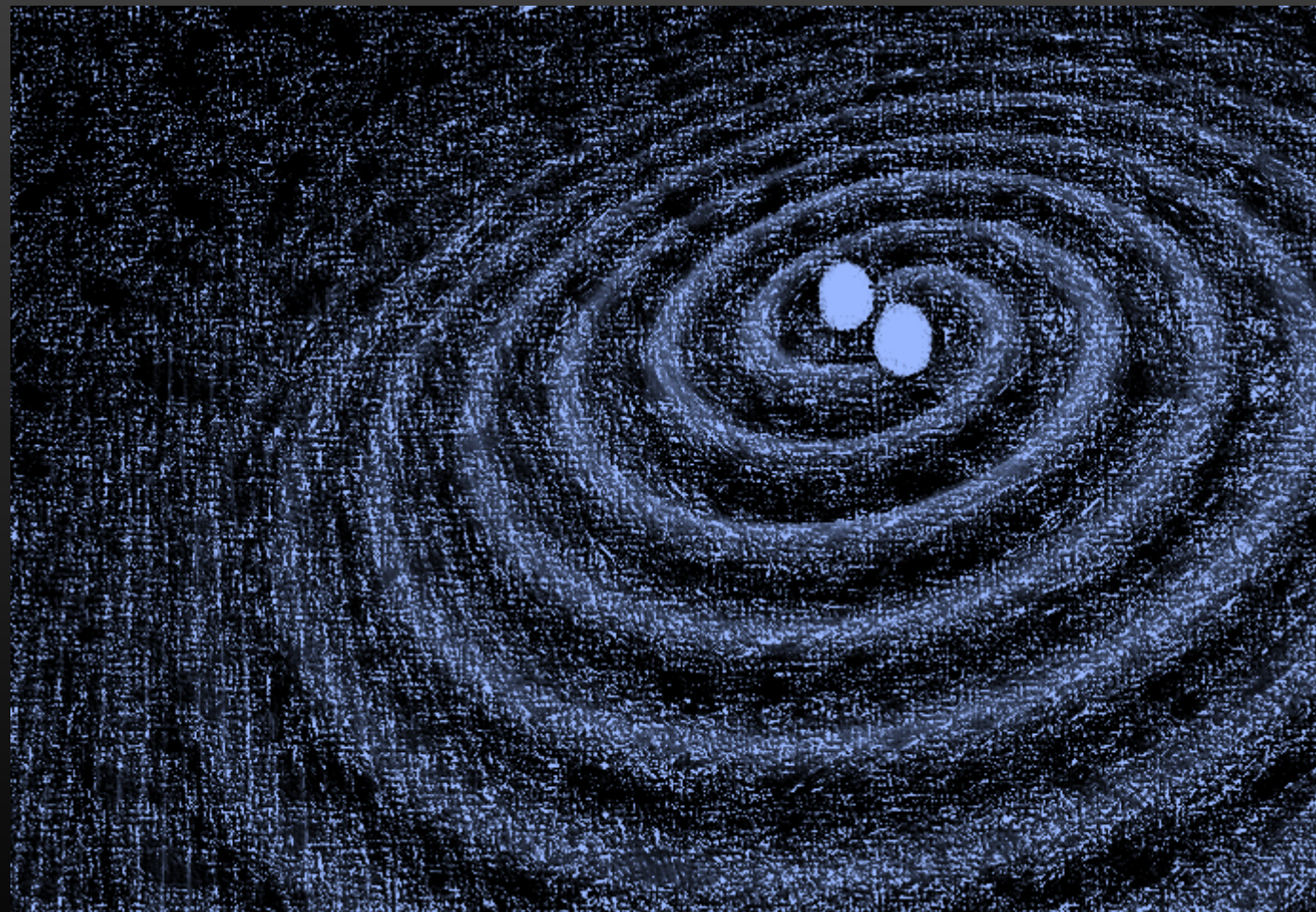
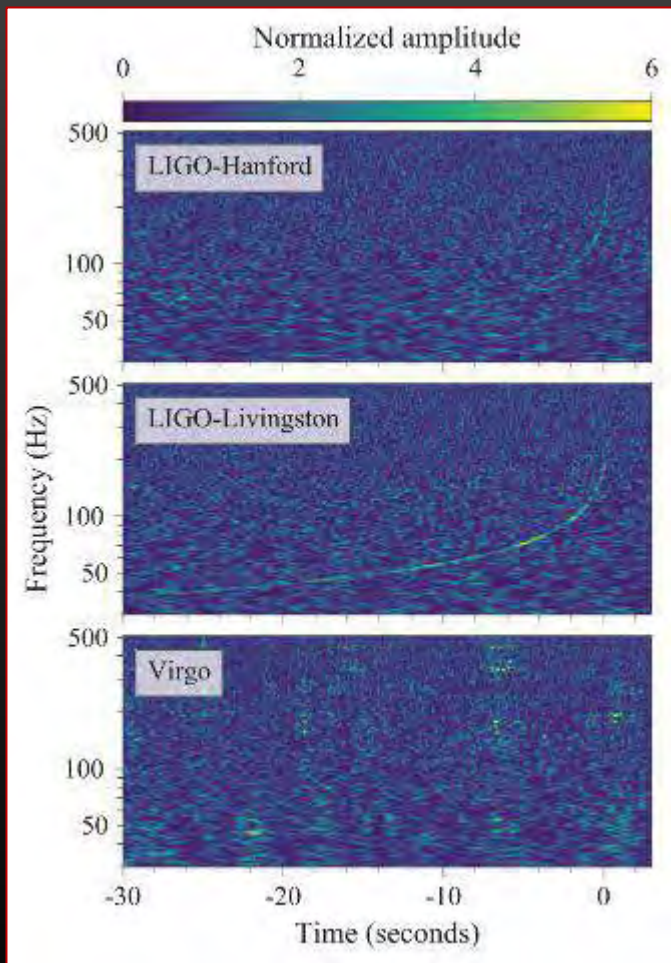


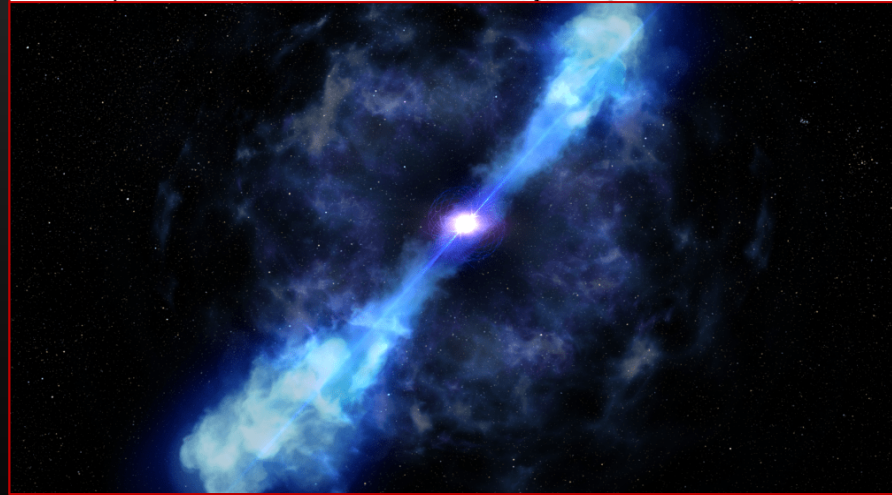
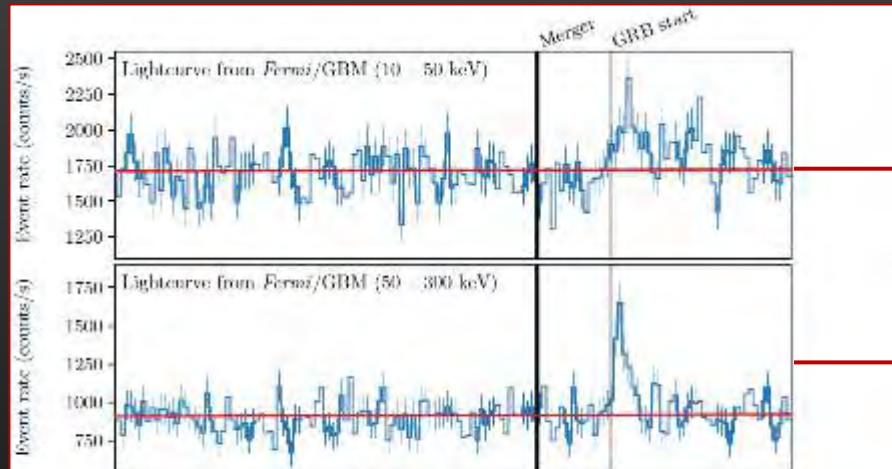
# Når Stjerner Kolliderer

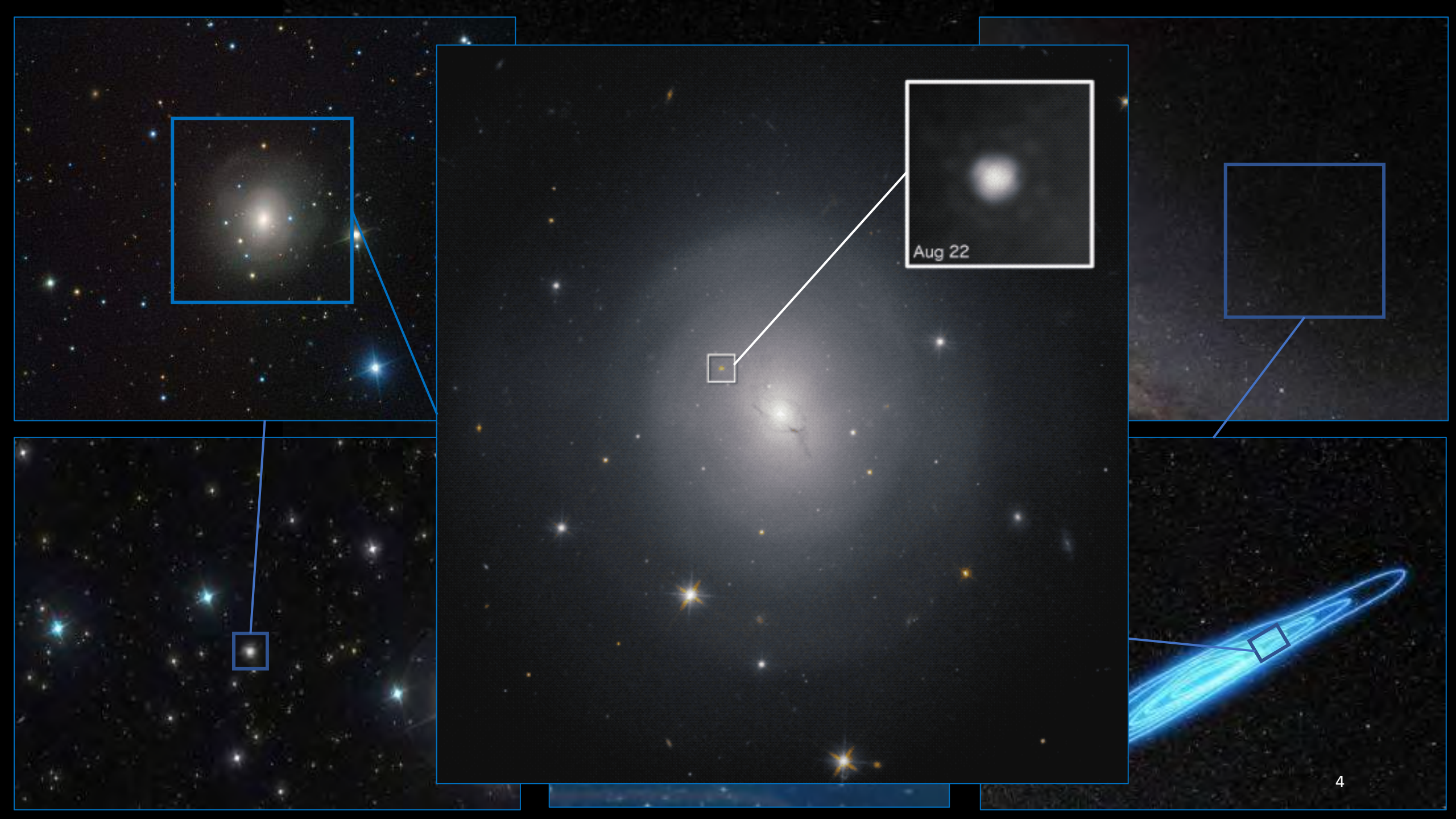
Albert Bjerregård Sneppen

The Niels Bohr Institute & The Cosmic DAWN Center

# Den 17. August 2017...







Aug 22



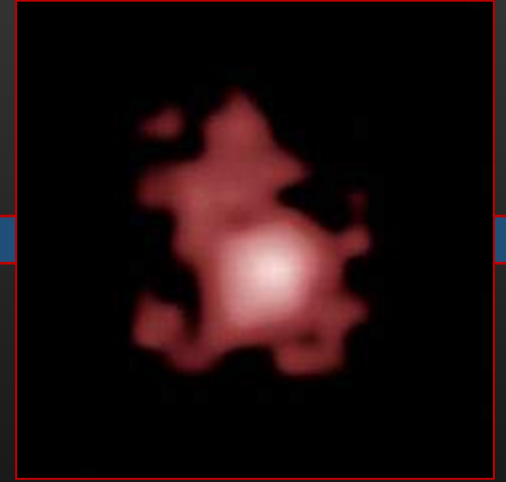
*1 second*



*4 years*



*2.500.000 years*



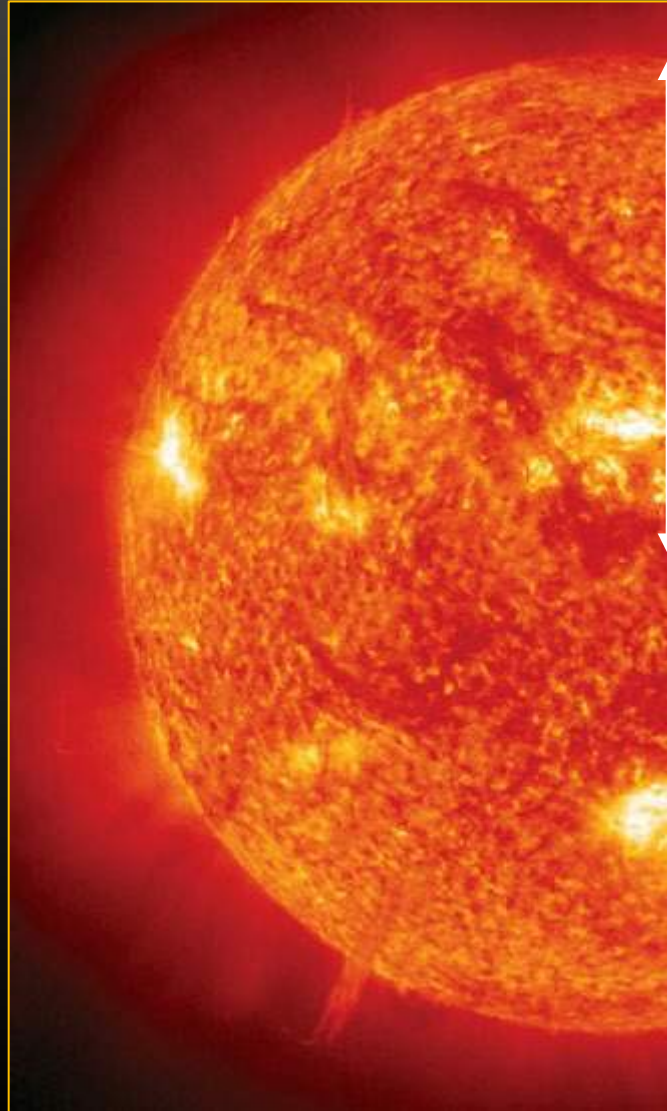
*13.400.000.000 years*



Ca. 140 millioner lysår  
1.320.000.000.000.000.000.000 km



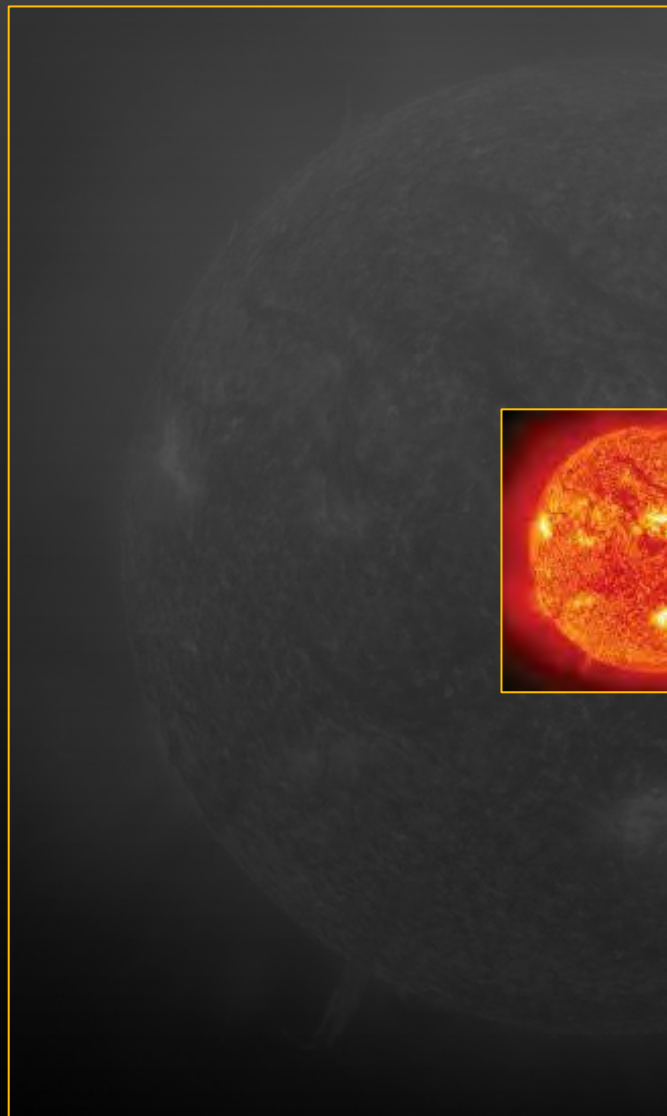
# Oprindelsen af Neutron-stjerner



700.000 km

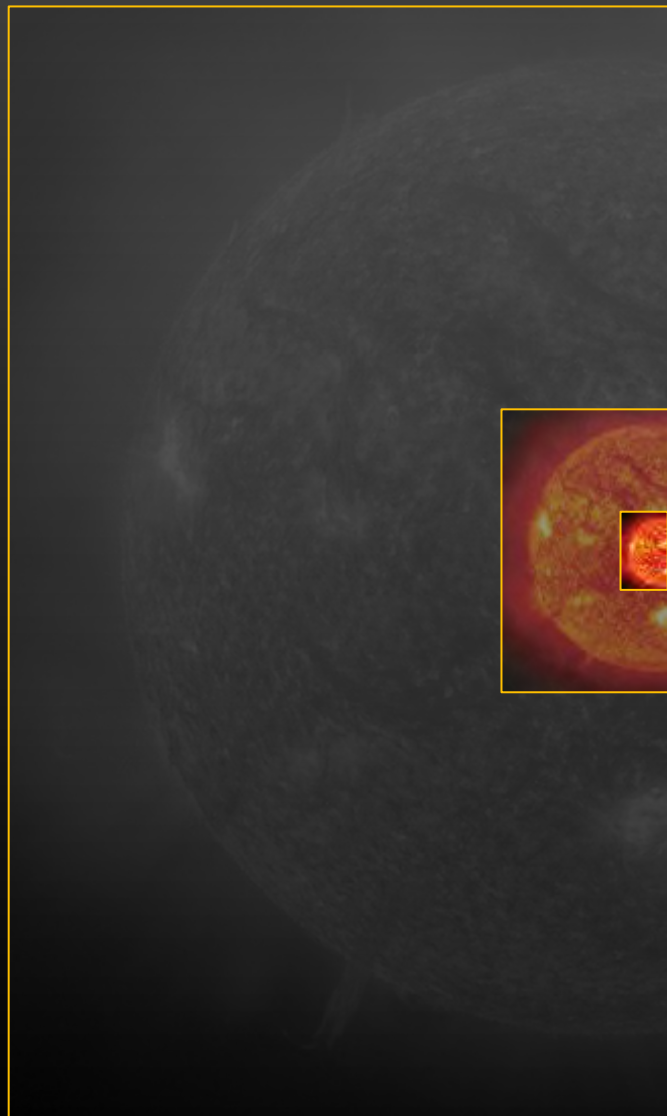
Det ville svare til afstanden man kunne køre på motorvejen 120 km/t, 24 timer i døgnet i 8 måneder!

# Oprindelsen af Neutron-stjerner

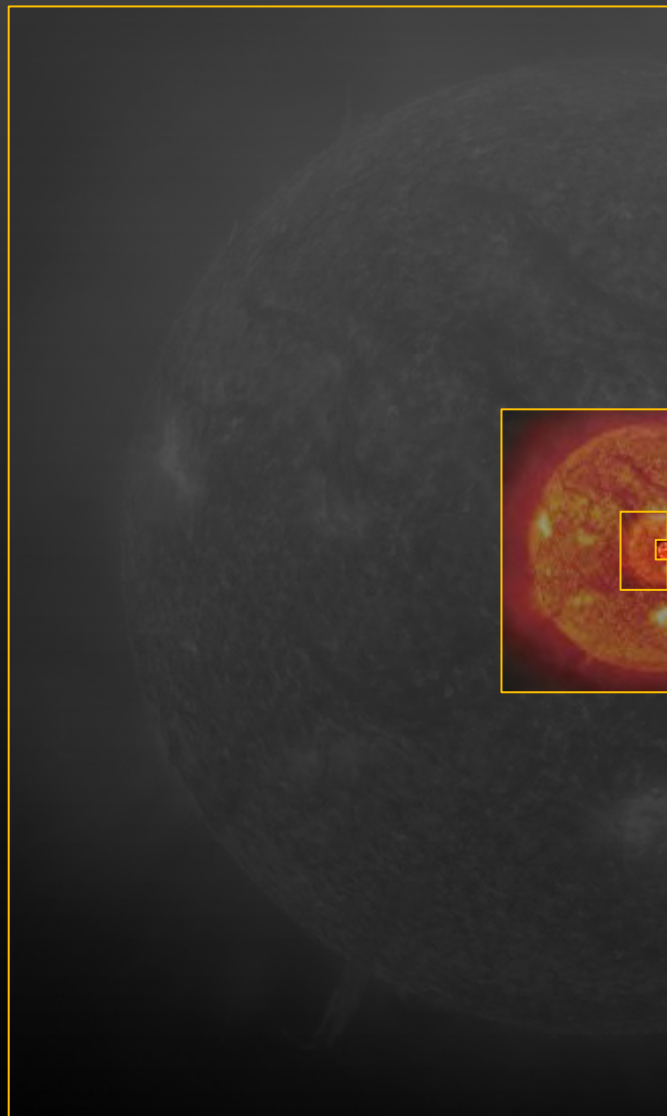




# Oprindelsen af Neutron-stjerner



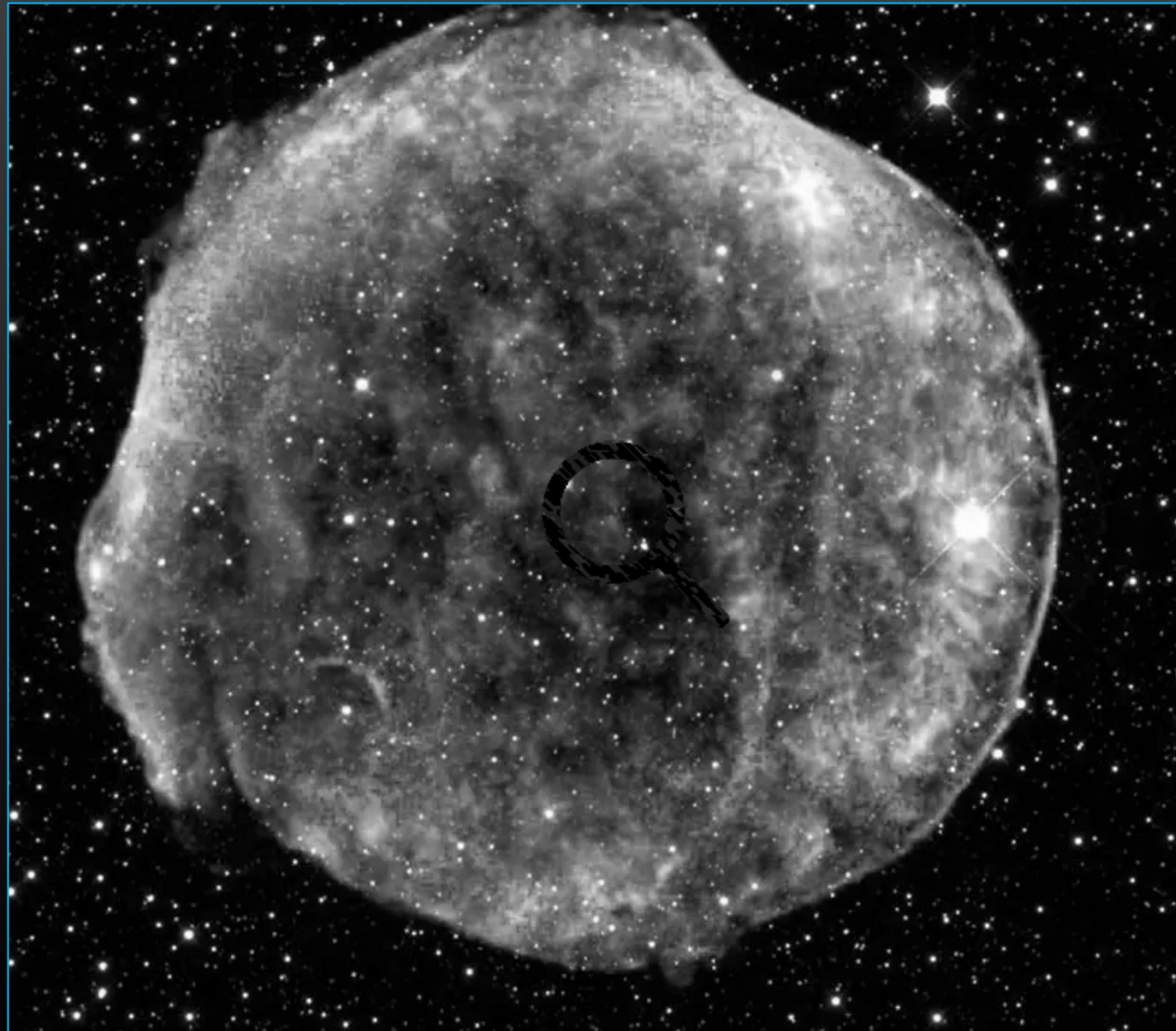
# Oprindelsen af Neutron-stjerner



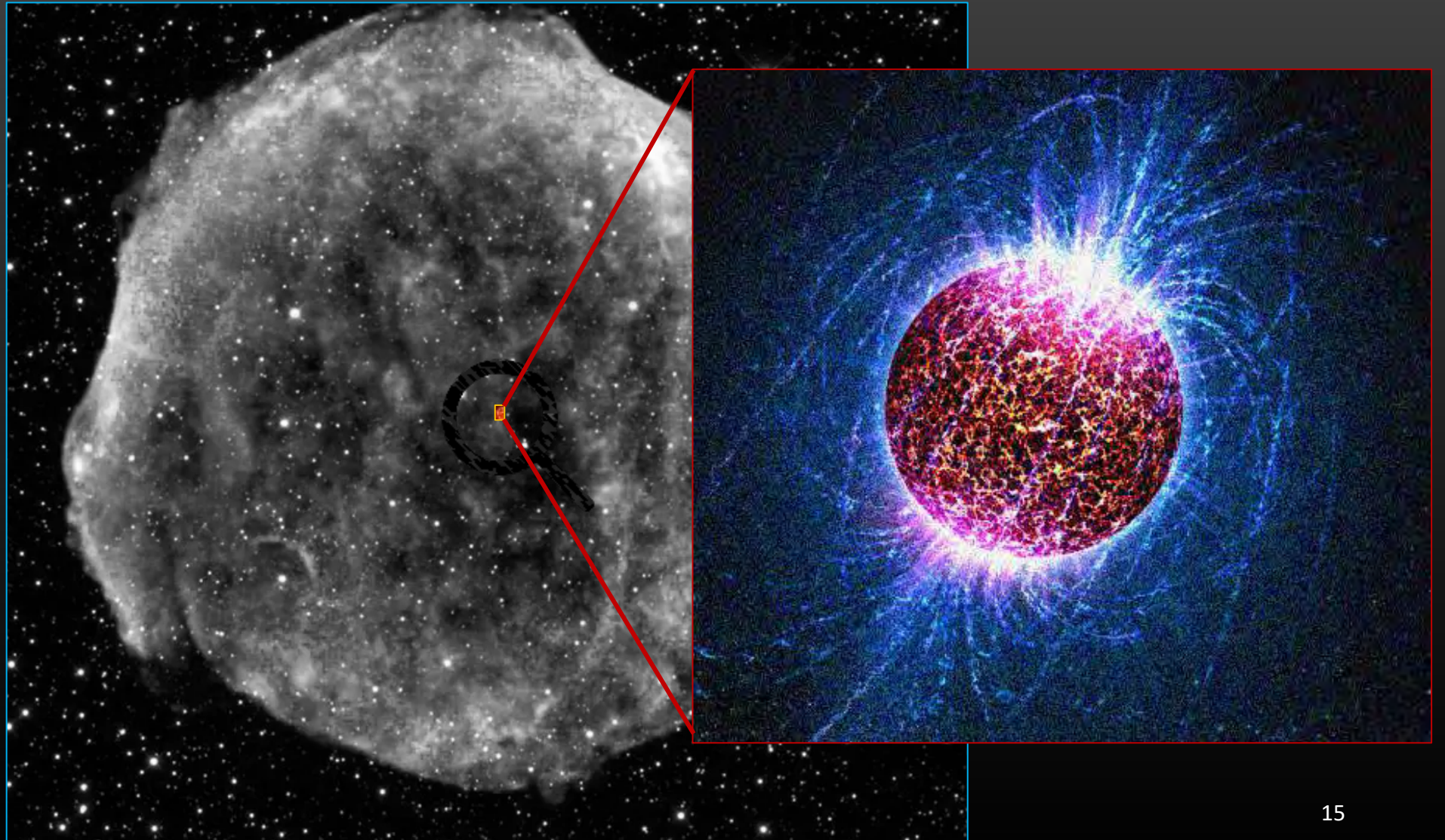
# Supernova til neutron-stjerner



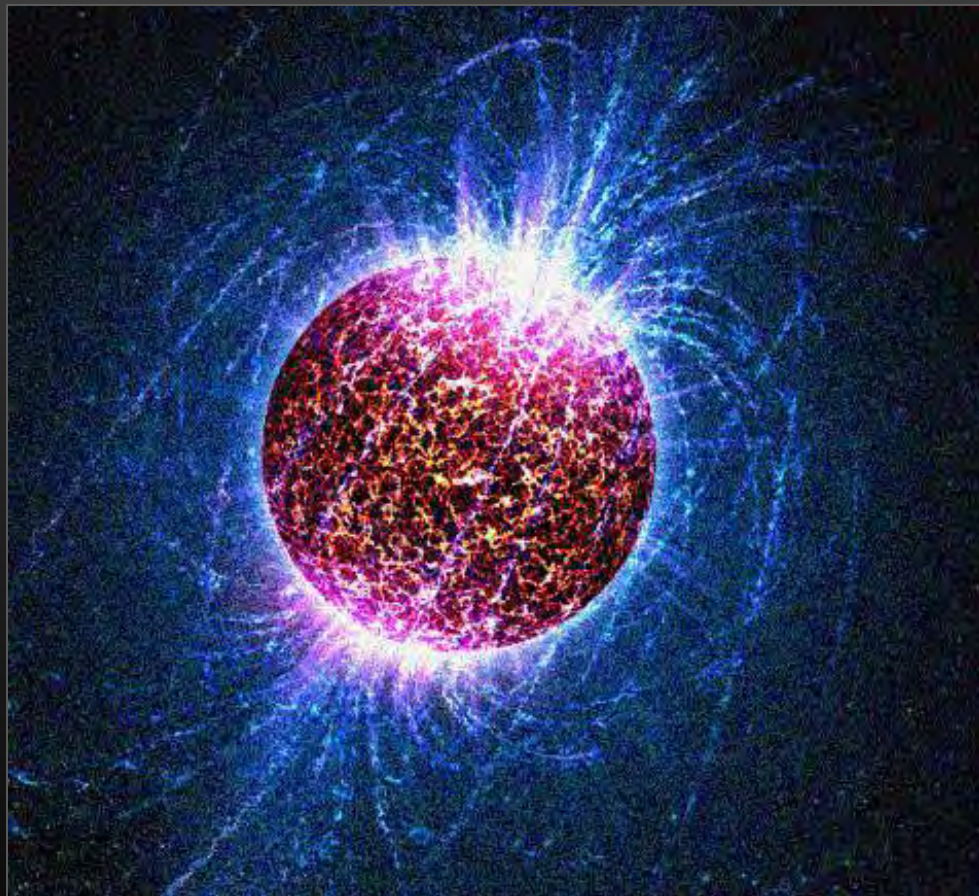
# Supernova til neutron-stjerner



# Supernova til neutron-stjerner



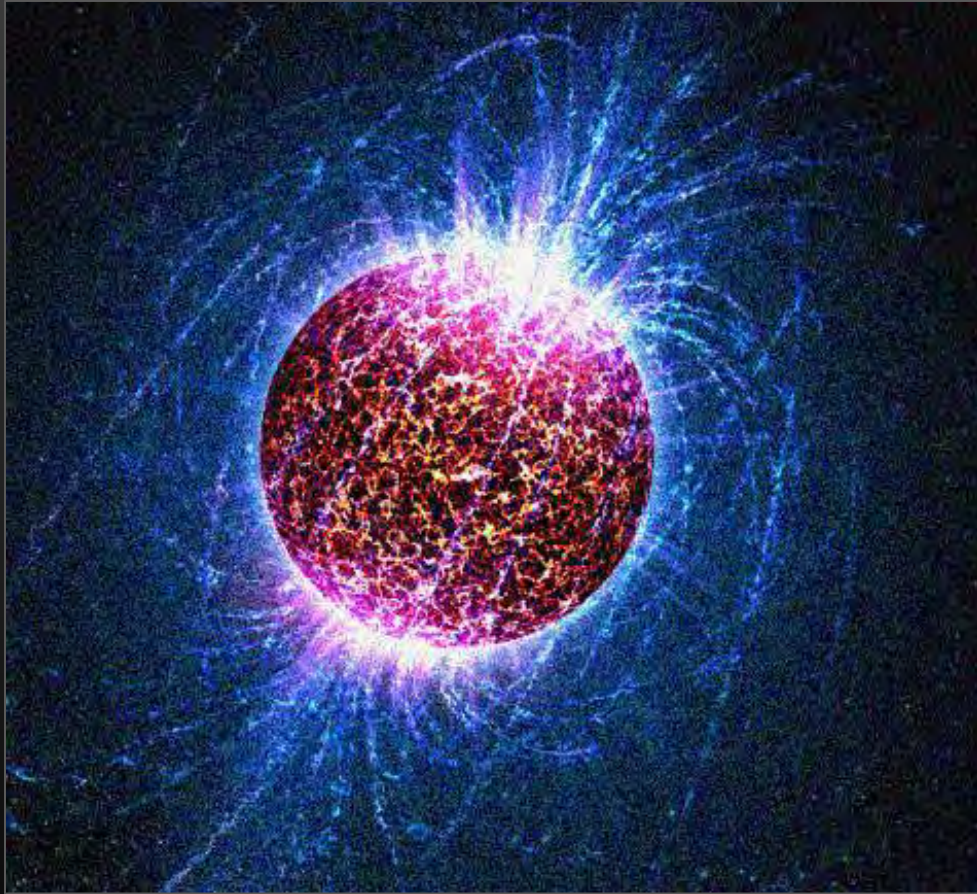
# Neutron-stjerner



De tætteste objekter i Universet

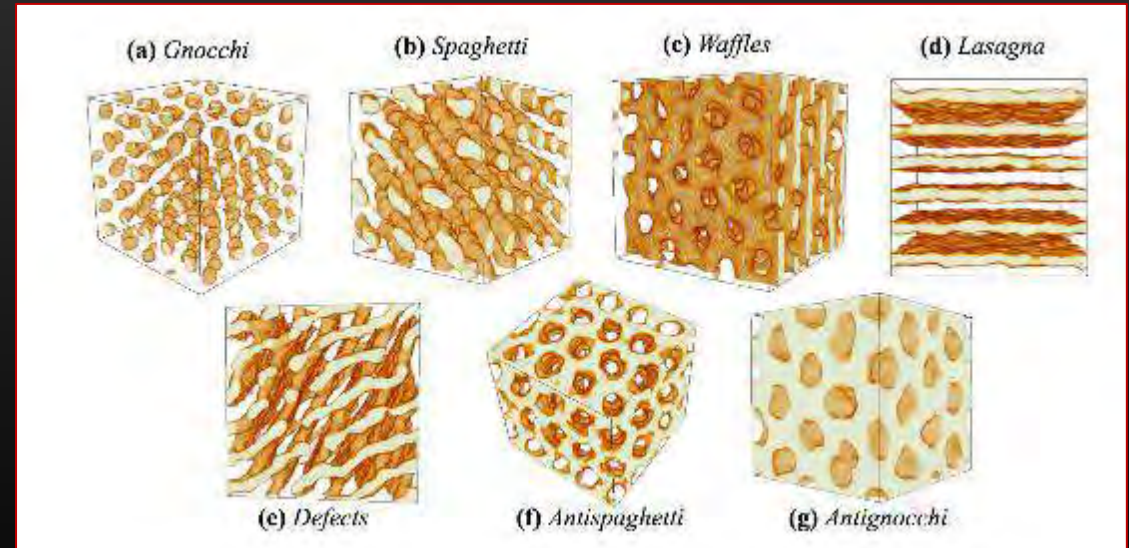
- 100 millioner tons i en centicube
- Ligeså tæt som en atom-kerne

# Neutron-stjerner

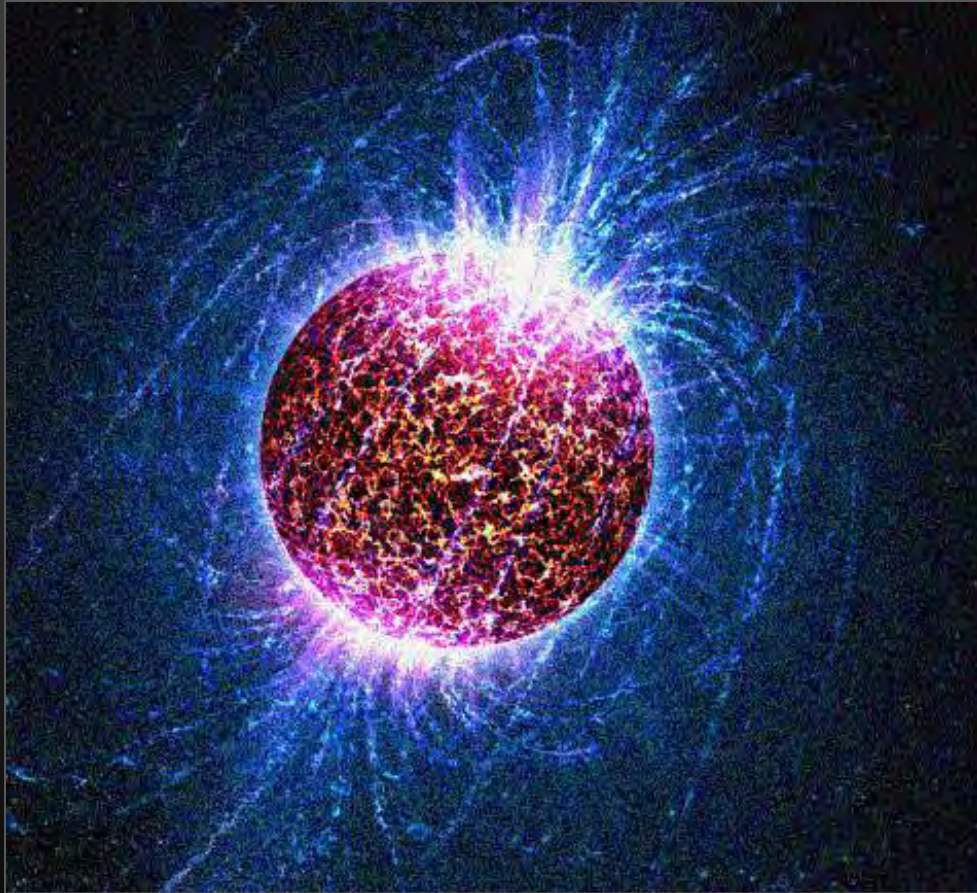


De stærkeste magneter i Universet:

Magnetstyrke op til million milliard gange større end på Jorden.



# Neutron-stjerner



De tætteste objekter i Universet

De stærkeste magneter i Universet

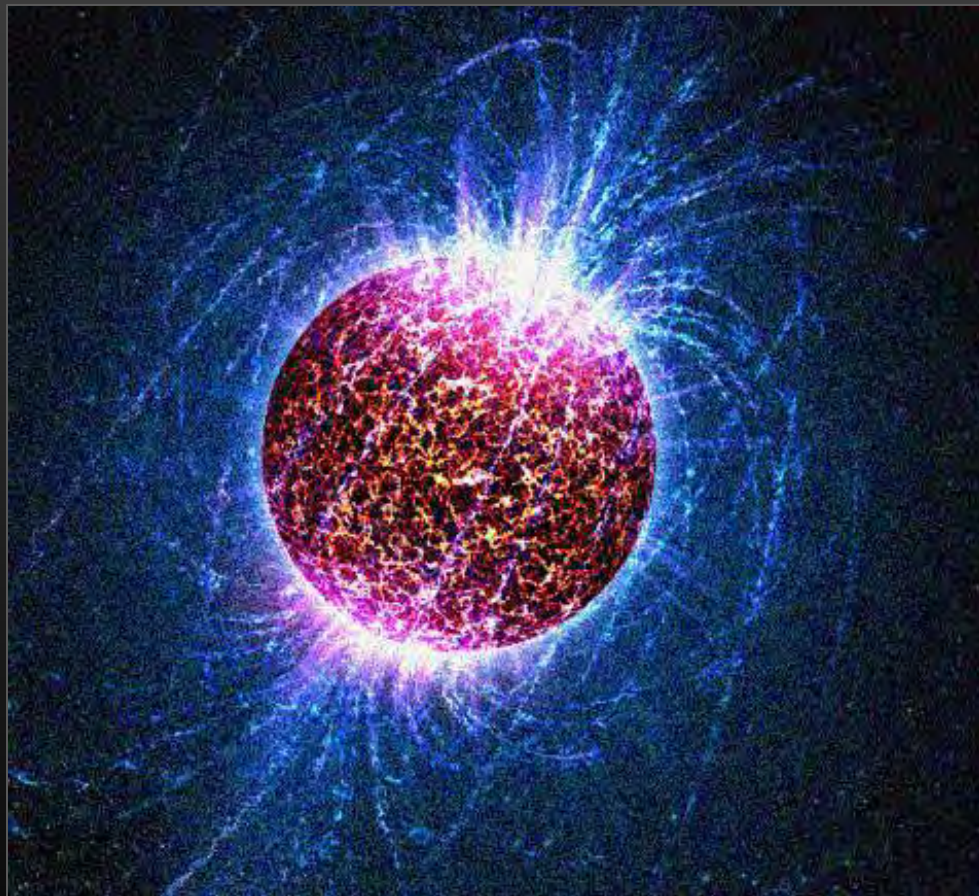
De mest præcise ur i Universet

De mindste bjerge i Universet

Nær den gravitationelle grænse af Sorte Huller  
(bagsiden af en neutron-stjerne...)



# Neutron-stjerne

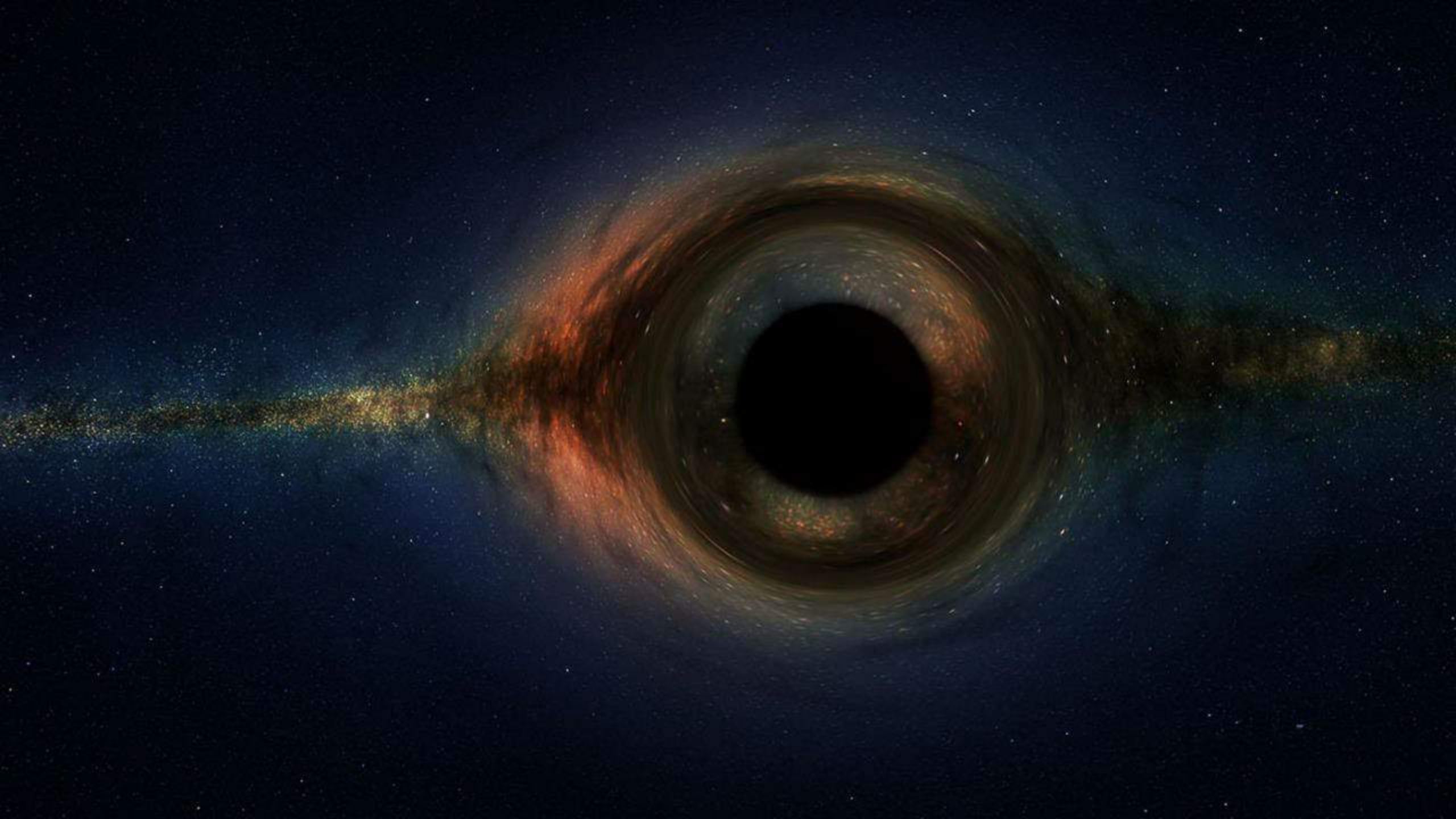


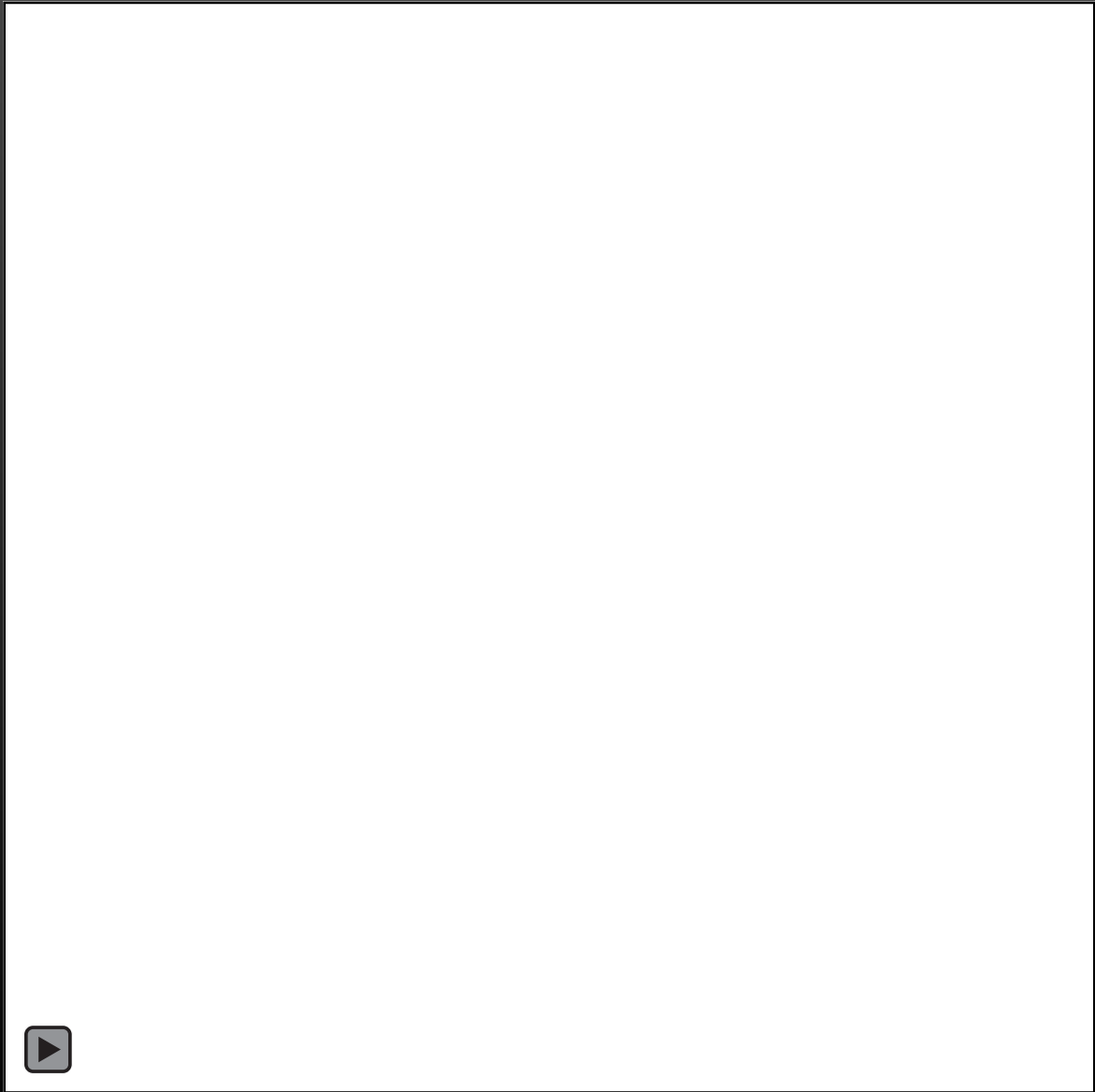
# Kilonova





# Sort Huls Fødsel















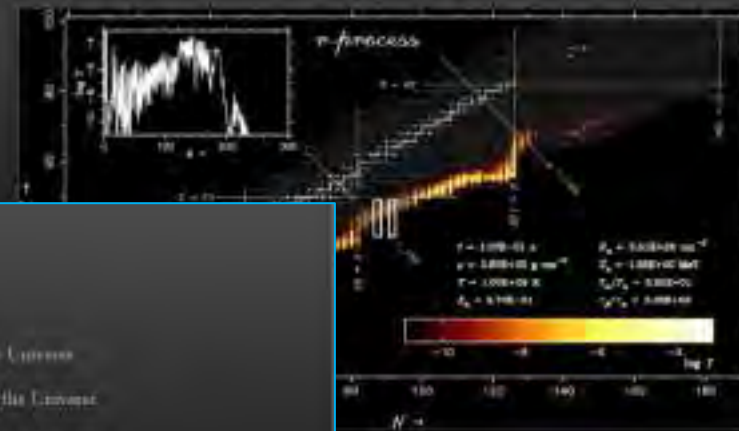


# Oprindelsen af (*tunge*) grundstoffer

A periodic table of elements with red circles highlighting Molybdenum (Mo), Iodine (I), Thorium (Th), and Uranium (U). The table is color-coded by groups: Alkali metals (red), Alkaline earth metals (orange), Lanthanides (yellow), Actinides (green), Transition metals (blue), Transition metals (purple), Metalloids (light blue), Reactive nonmetals (dark blue), Halogens (teal), Noble gases (light green), and Unknowns (dark green).

1	2	3-10	11	12	13	14	15	16	17	18																					
IA	IIA	IIIB	IVB	VB	VIB	VII	VIII	VIIIA	VIIIB	VIIIA																					
1 H Hydrogen	2 He Helium																														
3 Li Lithium	4 Be Beryllium									5 B Boron	6 C Carbon	7 N Nitrogen	8 O Oxygen	9 F Fluorine	10 Ne Neon																
11 Na Sodium	12 Mg Magnesium									13 Al Aluminum	14 Si Silicon	15 P Phosphorus	16 S Sulfur	17 Cl Chlorine	18 Ar Argon																
19 K Potassium	20 Ca Calcium	21 Sc Scandium	22 Ti Titanium	23 V Vanadium	24 Cr Chromium	25 Mn Manganese	26 Fe Iron	27 Co Cobalt	28 Ni Nickel	29 Cu Copper	30 Zn Zinc	31 Ga Gallium	32 Ge Germanium	33 As Arsenic	34 Se Selenium	35 Br Bromine	36 Kr Krypton														
37 Rb Rubidium	38 Sr Strontium	39 Y Yttrium	40 Zr Zirconium	41 Nb Niobium	42 Mo Molybdenum	43 Tc Technetium	44 Ru Ruthenium	45 Rh Rhodium	46 Pd Palladium	47 Ag Silver	48 Cd Cadmium	49 In Indium	50 Sn Tin	51 Sb Antimony	52 Te Tellurium	53 I Iodine	54 Xe Xenon														
55 Cs Cesium	56 Ba Barium	57 La Lanthanum	58 Ce Cerium	59 Pr Praseodymium	60 Nd Neodymium	61 Pm Promethium	62 Sm Samarium	63 Eu Europium	64 Gd Gadolinium	65 Tb Terbium	66 Dy Dysprosium	67 Ho Holmium	68 Er Erbium	69 Tm Thulium	70 Yb Ytterbium	71 Lu Lutetium	72 Hf Hafnium	73 Ta Tantalum	74 W Tungsten	75 Re Rhenium	76 Os Osmium	77 Ir Iridium	78 Pt Platinum	79 Au Gold	80 Hg Mercury	81 Tl Thallium	82 Pb Lead	83 Bi Bismuth	84 Po Polonium	85 At Astatine	86 Rn Radon
87 Fr Francium	88 Ra Radium	89 Ac Actinium	90 Th Thorium	91 Pa Protactinium	92 U Uranium	93 Np Neptunium	94 Pu Plutonium	95 Am Americium	96 Cm Curium	97 Bk Berkelium	98 Cf Californium	99 Es Einsteinium	100 Fm Fermium	101 Md Mendelevium	102 No Nobelium	103 Lr Lawrencium	104 Rf Rutherfordium	105 Db Dubnium	106 Sg Seaborgium	107 Bh Bohrium	108 Hs Hassium	109 Mt Meitnerium	110 Ds Darmstadtium	111 Rg Roentgenium	112 Cn Copernicium	113 Nh Nihonium	114 Fl Flerovium	115 Mc Moscovium	116 Lv Livermorium	117 Ts Tennessine	118 Og Oganesson
119 Uue Ununennium	120 Ubn Unbinilium	121 Ubu Untrium																													

## The Origin of the (heavy) Elements



## Neutron Stars



- Densest objects in the Universe
- Strongest magnets in the Universe
- Most precise clocks in the Universe
- Can be the hottest stars in the Universe
- Smallest mountains in the Universe
- At the gravitational limit of black holes (you can see the back of a neutron star)

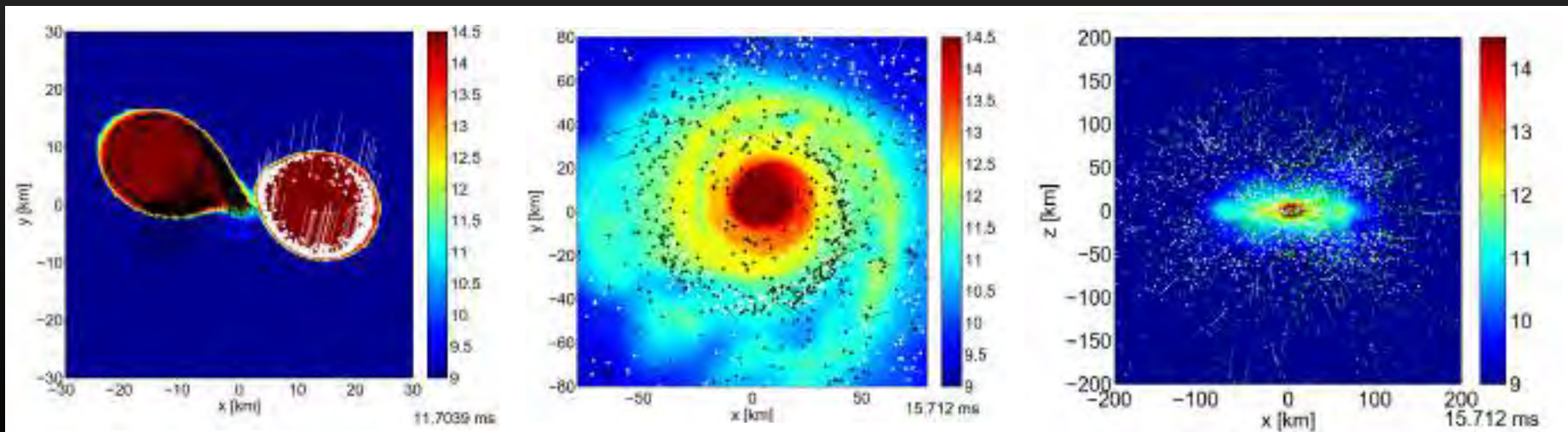
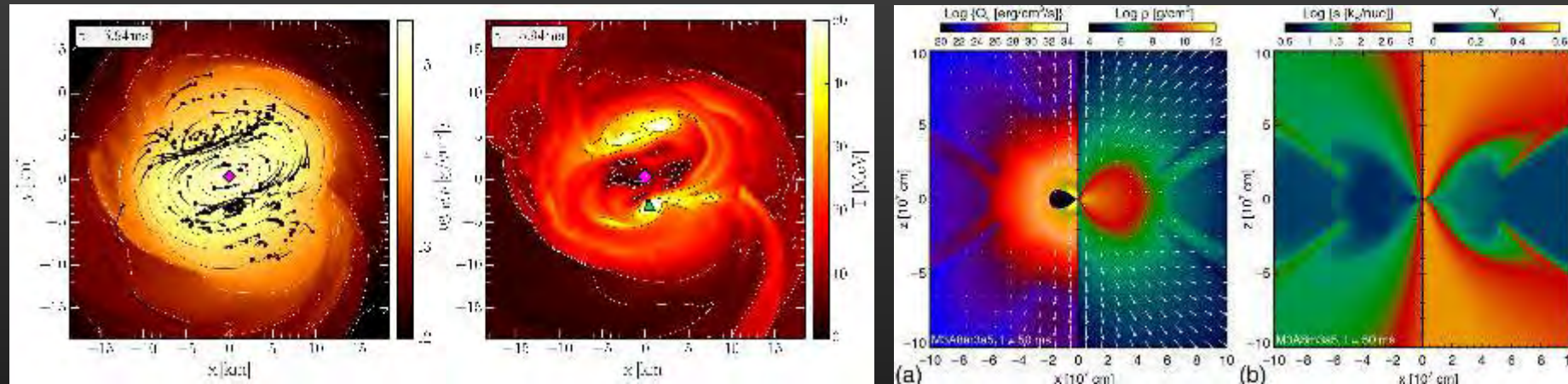
## Black Hole Formation



# Eksplosionens form

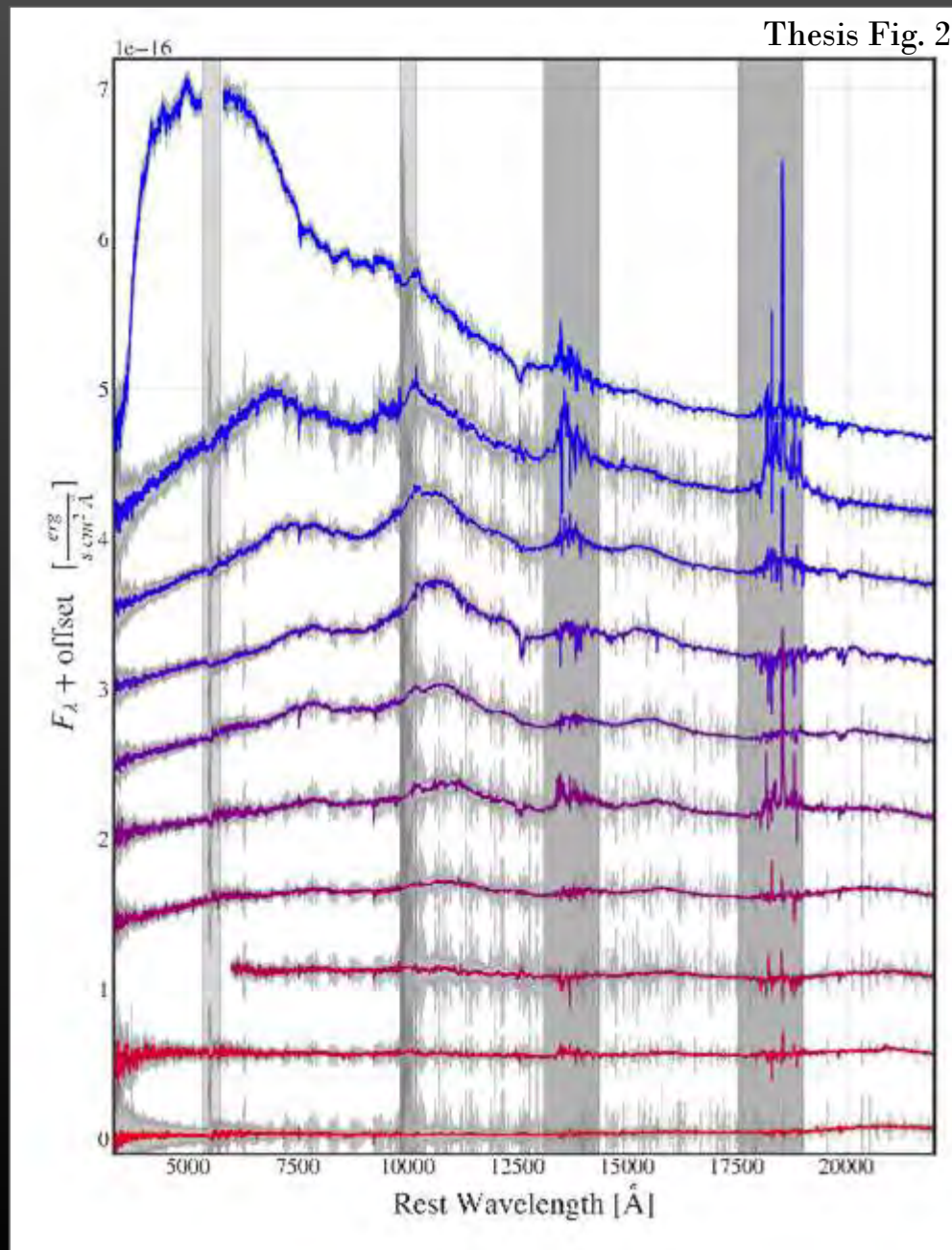
Hanauske 2019

Just 2015



Bauswein 2013

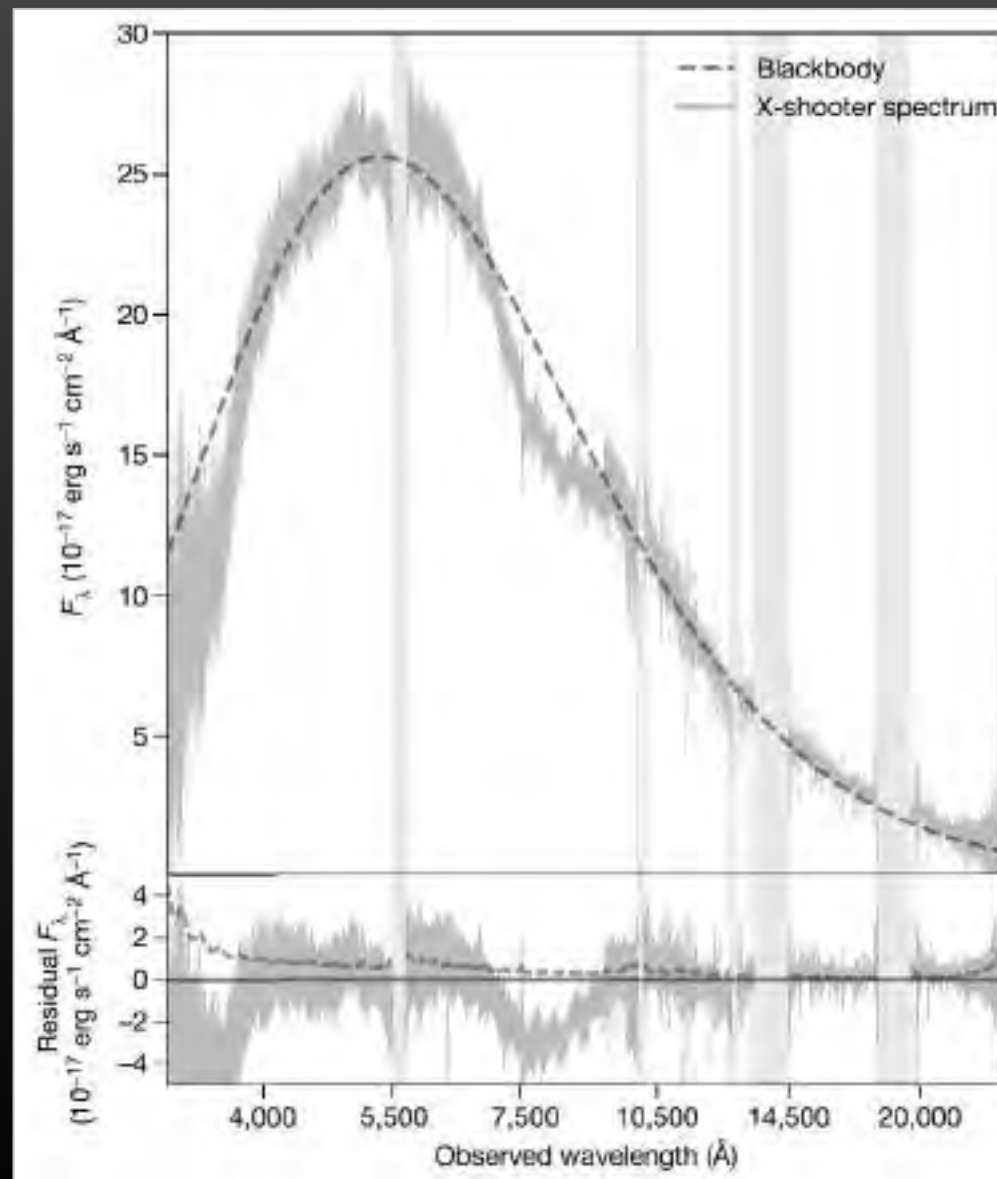
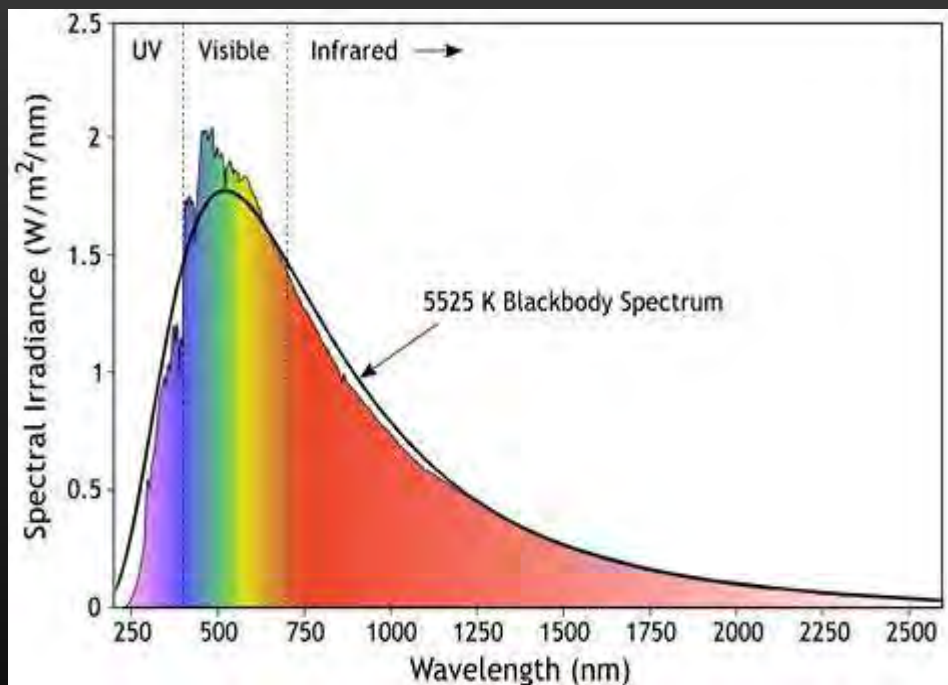
Transient astrofysisk objekt med lysstyrken,  $10^9 L_{\odot}$ ,  
men som forsvandt i løbet af nogle dage...



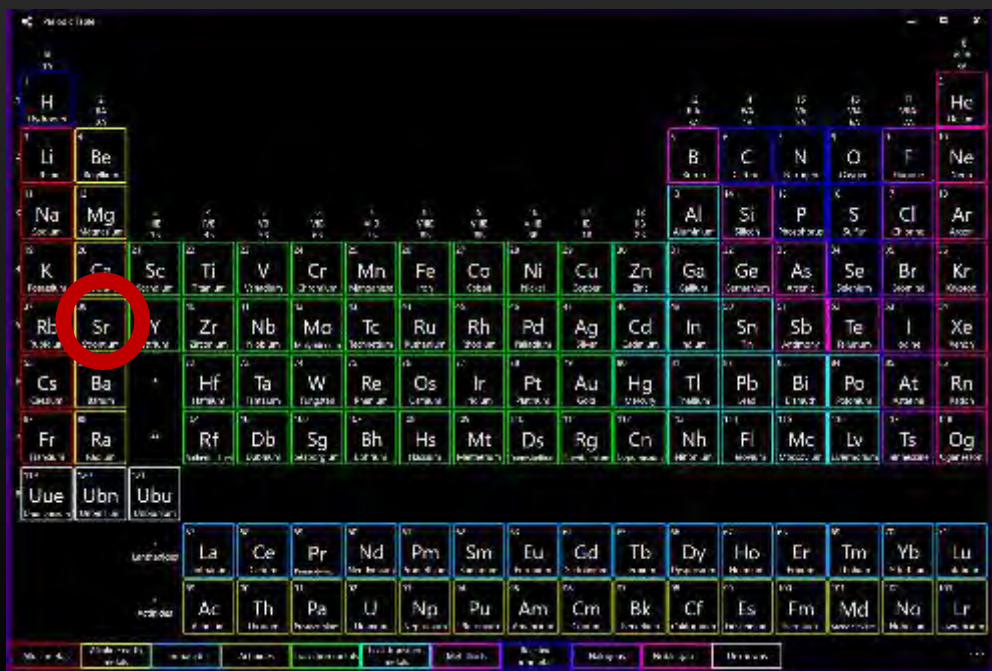
# AT2017gfo

Watson et al. (2019)

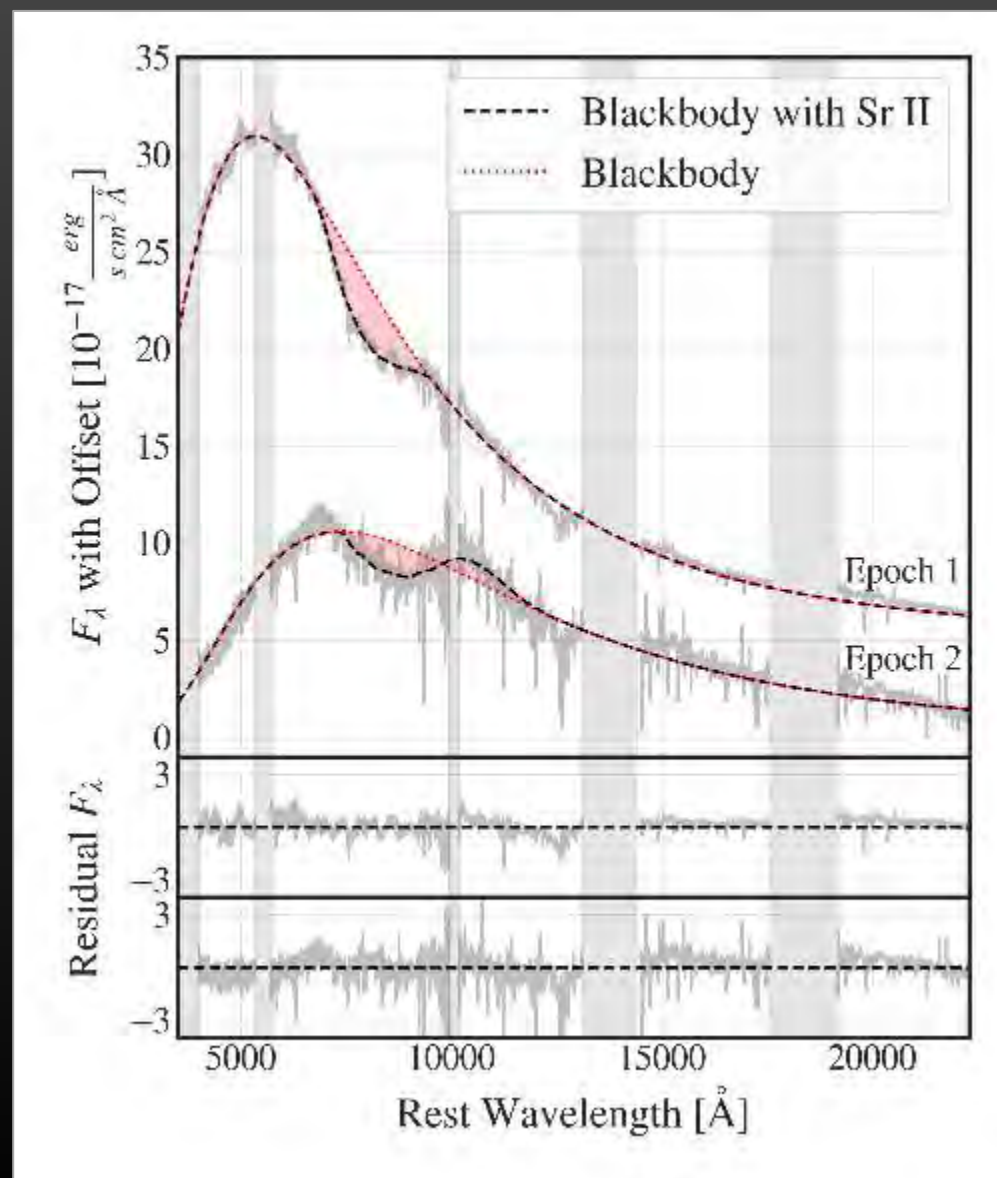
Solens farver



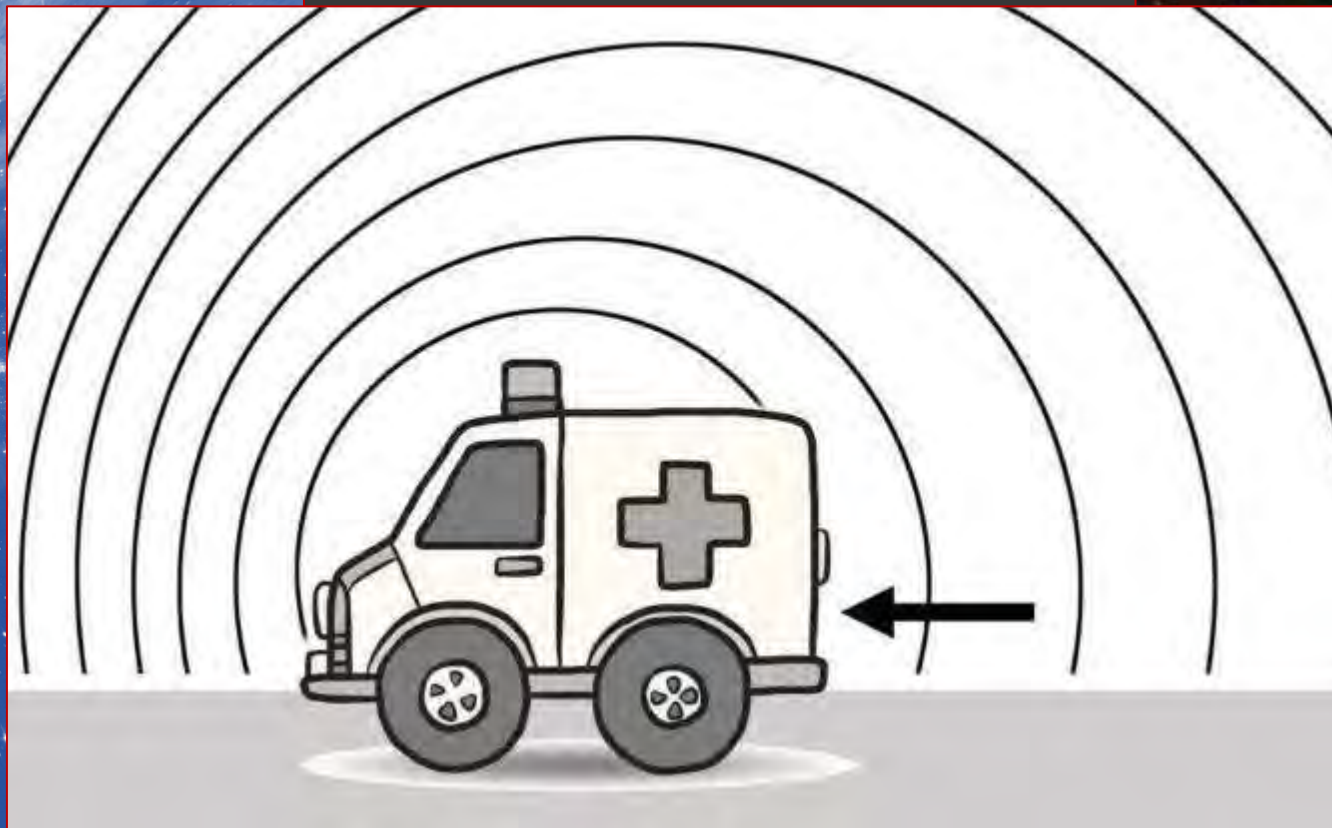
# AT2017gfo



X-shooter spectrum epoch 1+2

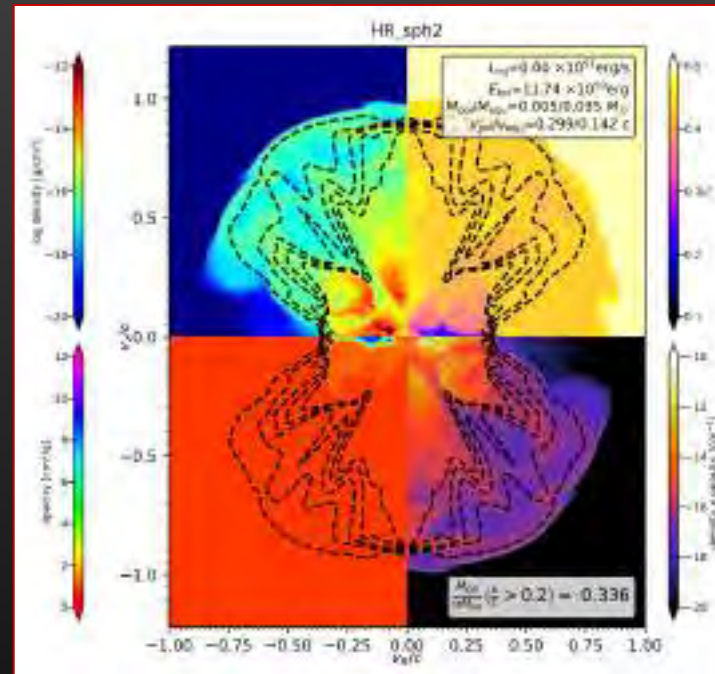
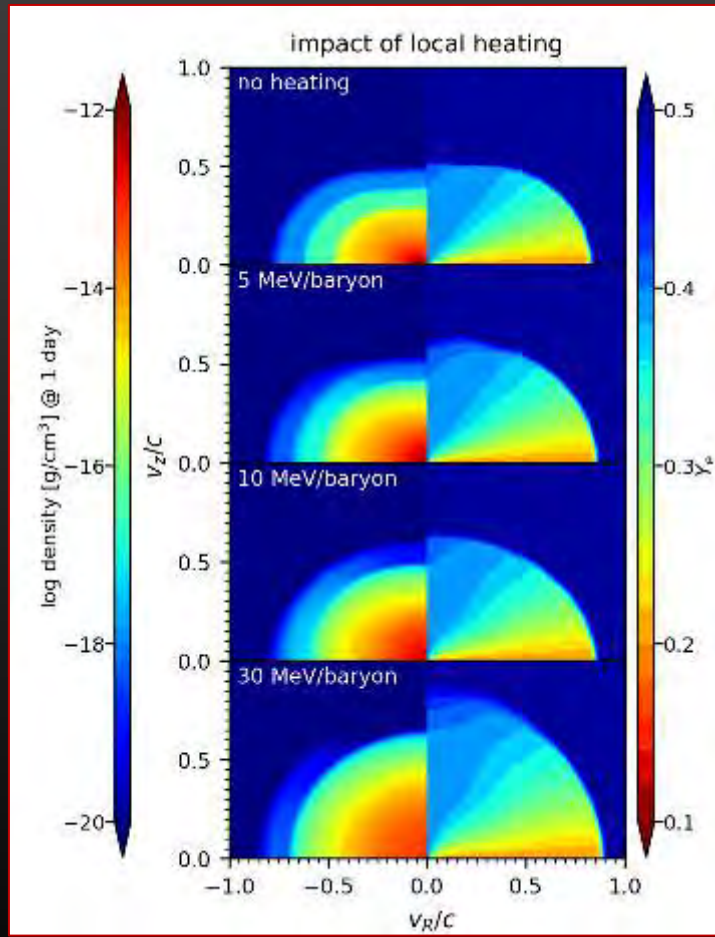


# Doppler-effekten

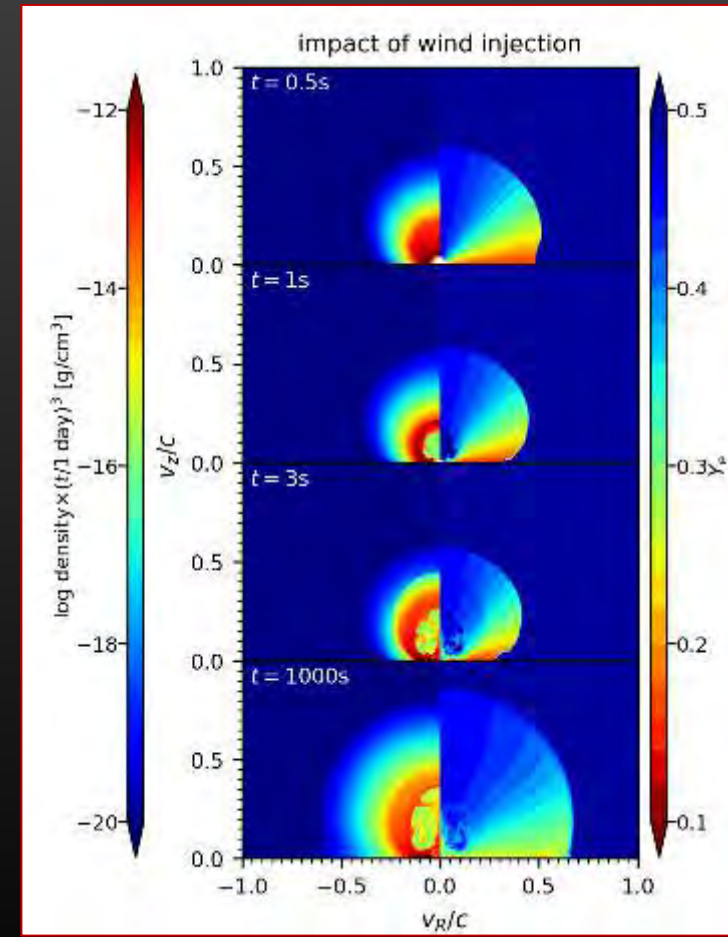




# Mysteriet i eksplosionens kerne



Produceret af Oliver Just



# Universets alder

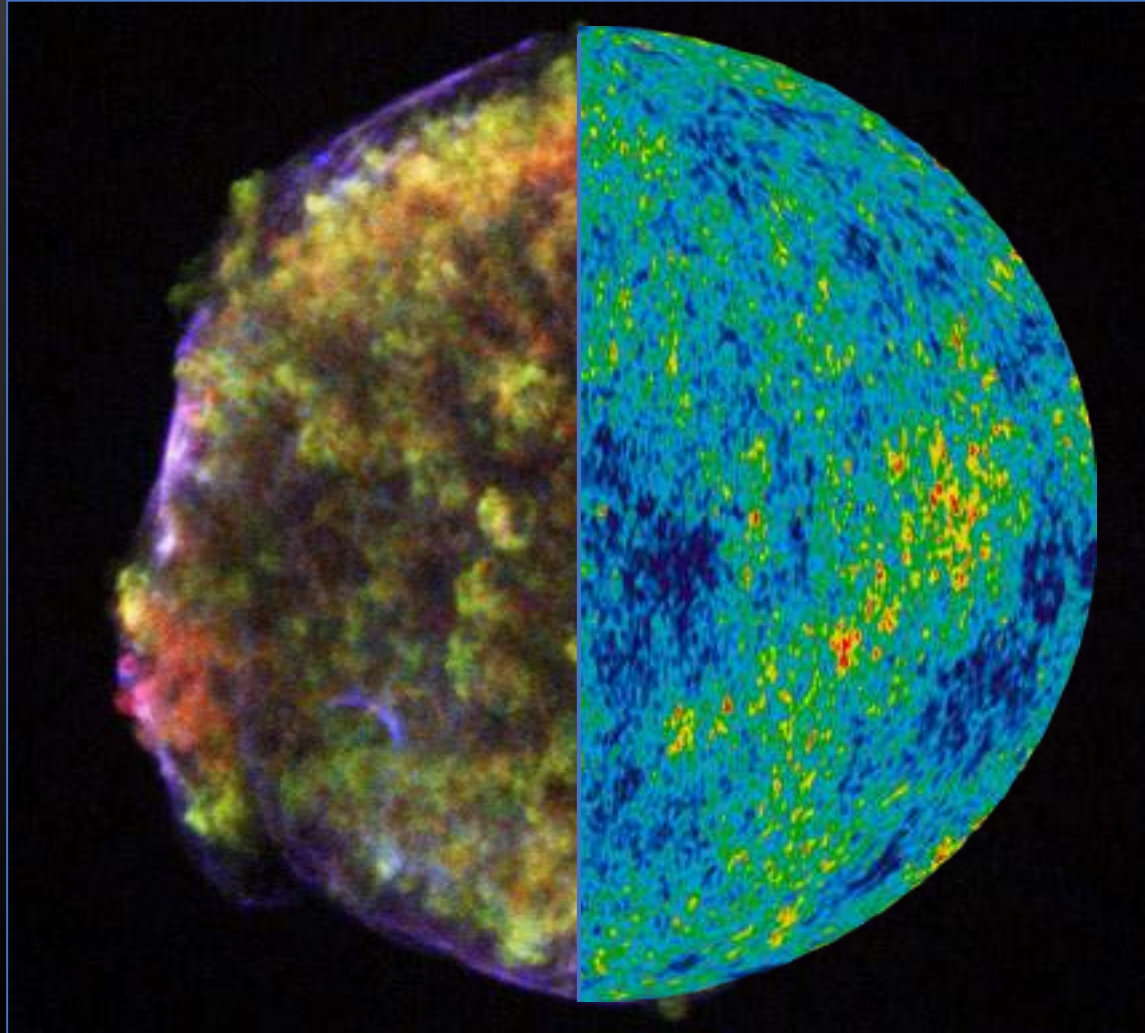


# Universets alder

## Lokale Målinger

$$H_0 = 74.0 \pm 1.0 \frac{\text{km}}{\text{s} \cdot \text{Mpc}}$$

12.8 Milliarder År Gammelt



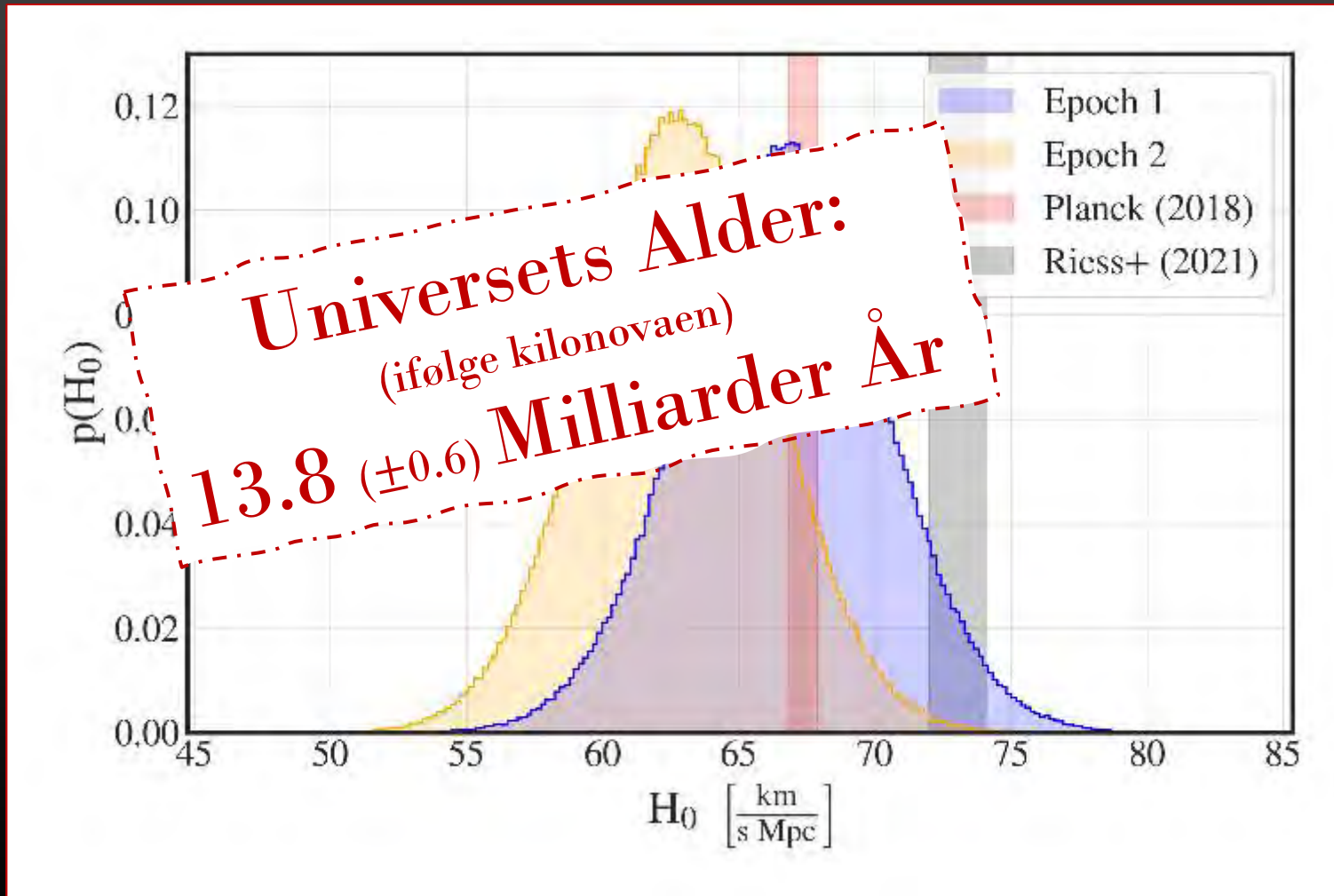
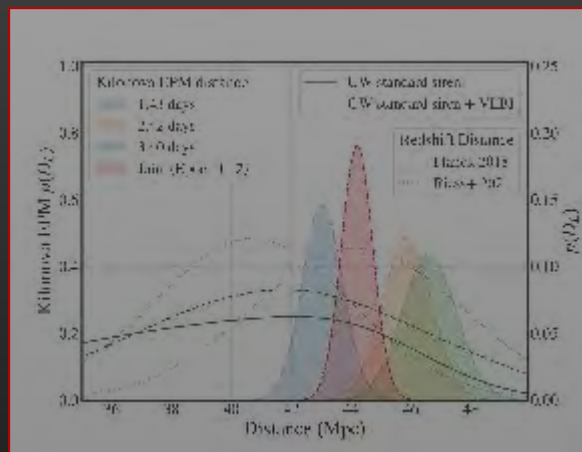
## Det Tidlige Univers

$$H_0 = 67.5 \pm 0.5 \frac{\text{km}}{\text{s} \cdot \text{Mpc}}$$

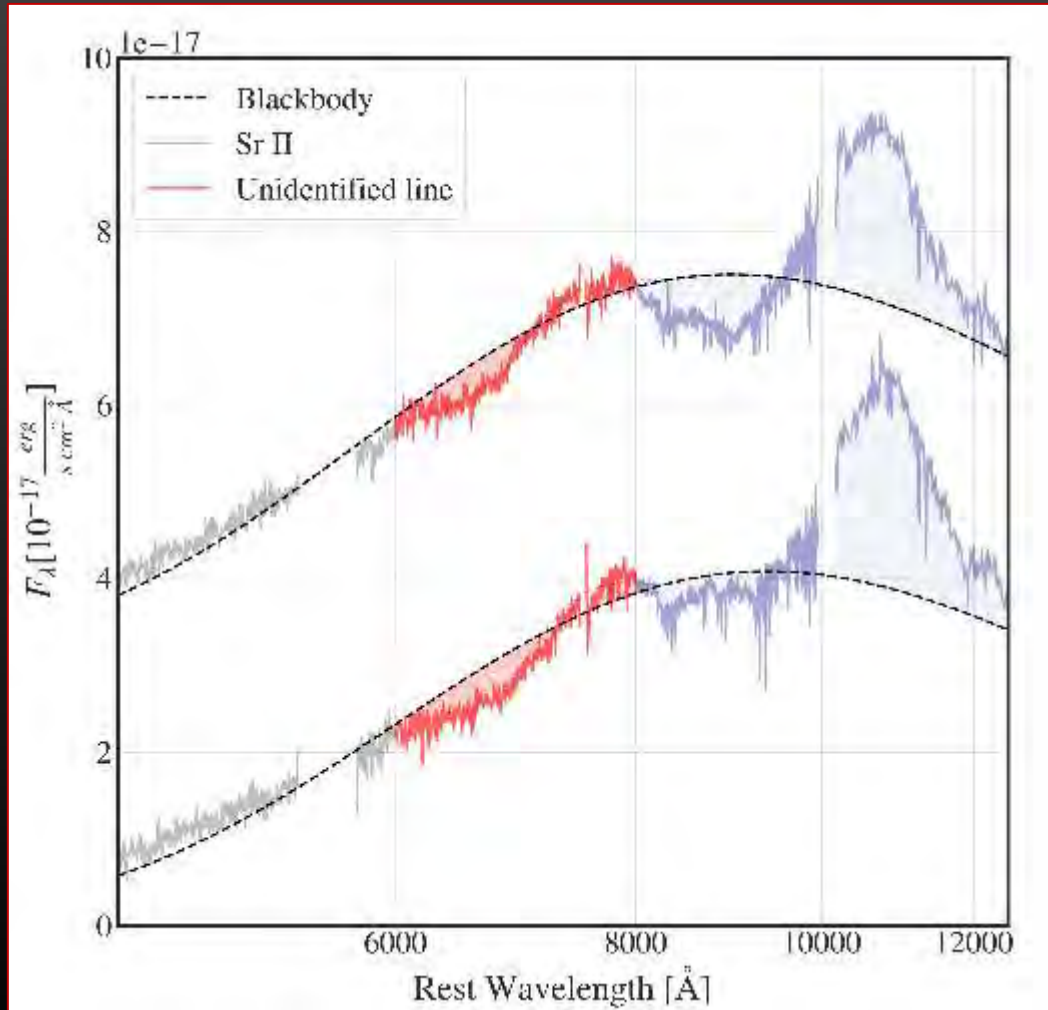
13.8 Milliarder År Gammelt

Universets alder er stadig ukendt!

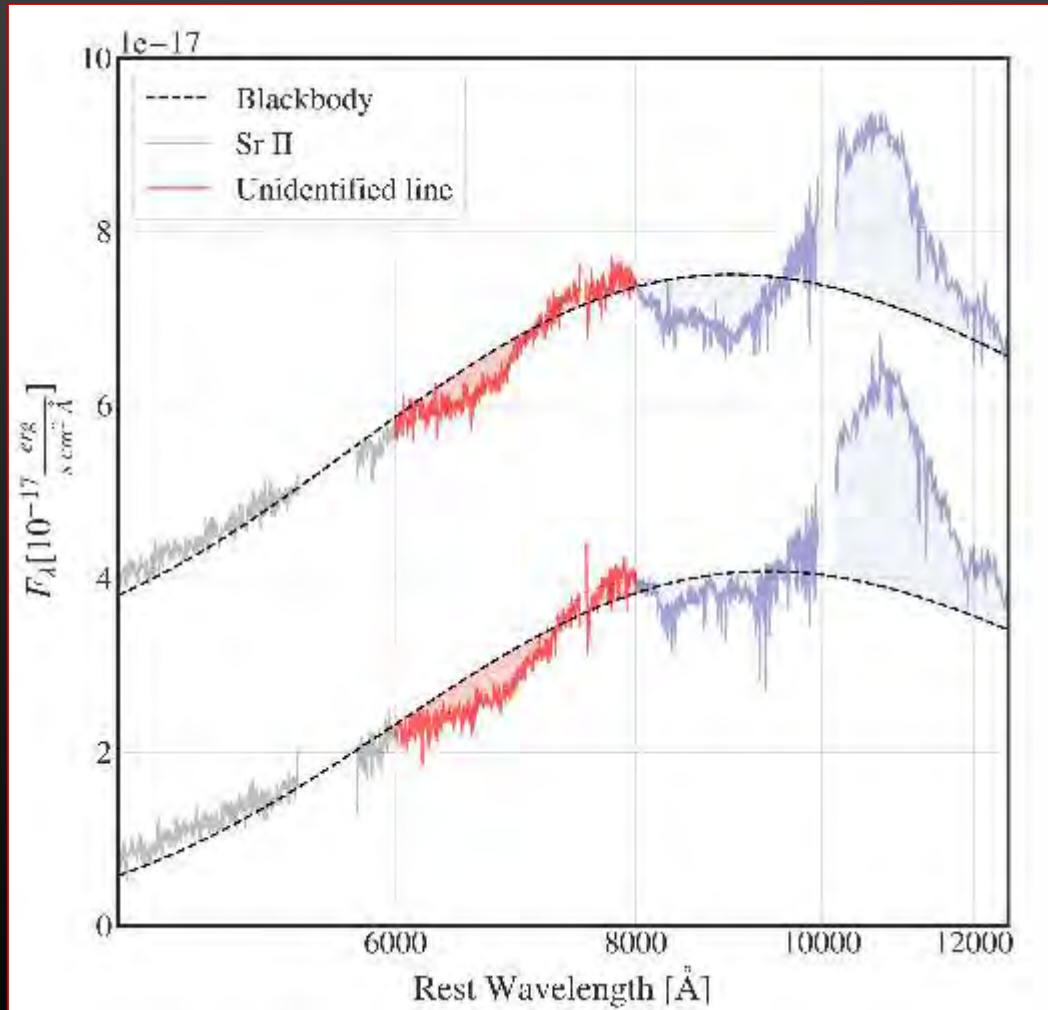
# Vores Nye Målinger af Universets alder



# Ny Atom-linje



# Yttrium!



The figure shows a standard periodic table of elements. The element Yttrium (Y) is highlighted with a blue border. It is located in the d-block, specifically in the 5th period and the 3rd column of the transition metals. The periodic table includes all elements from Hydrogen (H) to Oganesson (Og), with the lanthanide and actinide series shown below the main table.

1 IA																				18 VIIIA									
1 <b>H</b> Hydrogen 1.008																		2 <b>He</b> Helium 4.002602											
3 <b>Li</b> Lithium 6.94	4 <b>Be</b> Beryllium 9.012182											5 <b>B</b> Boron 10.81	6 <b>C</b> Carbon 12.011	7 <b>N</b> Nitrogen 14.007	8 <b>O</b> Oxygen 15.999	9 <b>F</b> Fluorine 18.99840323	10 <b>Ne</b> Neon 20.1797												
11 <b>Na</b> Sodium 22.98976928	12 <b>Mg</b> Magnesium 24.305											13 <b>Al</b> Aluminum 26.9815386	14 <b>Si</b> Silicon 28.0855	15 <b>P</b> Phosphorus 30.973761998	16 <b>S</b> Sulfur 32.06	17 <b>Cl</b> Chlorine 35.45	18 <b>Ar</b> Argon 39.948												
19 <b>K</b> Potassium 39.0983	20 <b>Ca</b> Calcium 40.078	21 <b>Sc</b> Scandium 44.955908	22 <b>Ti</b> Titanium 47.867	23 <b>V</b> Vanadium 50.9415	24 <b>Cr</b> Chromium 51.9961	25 <b>Mn</b> Manganese 54.938044	26 <b>Fe</b> Iron 55.845	27 <b>Co</b> Cobalt 58.933194	28 <b>Ni</b> Nickel 58.6934	29 <b>Cu</b> Copper 63.546	30 <b>Zn</b> Zinc 65.38	31 <b>Ga</b> Gallium 69.723	32 <b>Ge</b> Germanium 72.630	33 <b>As</b> Arsenic 74.921595	34 <b>Se</b> Selenium 78.971	35 <b>Br</b> Bromine 79.904	36 <b>Kr</b> Krypton 83.798												
37 <b>Rb</b> Rubidium 85.4678	38 <b>Sr</b> Strontium 87.62	39 <b>Y</b> Yttrium 88.90584	40 <b>Zr</b> Zirconium 91.224	41 <b>Nb</b> Niobium 92.90638	42 <b>Mo</b> Molybdenum 95.94	43 <b>Tc</b> Technetium [98]	44 <b>Ru</b> Ruthenium 101.07	45 <b>Rh</b> Rhodium 102.90550	46 <b>Pd</b> Palladium 106.42	47 <b>Ag</b> Silver 107.8682	48 <b>Cd</b> Cadmium 112.414	49 <b>In</b> Indium 114.818	50 <b>Sn</b> Tin 118.710	51 <b>Sb</b> Antimony 121.757	52 <b>Te</b> Tellurium 127.60	53 <b>I</b> Iodine 126.90447	54 <b>Xe</b> Xenon 131.293												
55 <b>Cs</b> Caesium 132.90545196	56 <b>Ba</b> Barium 137.327	57 - 71 Lanthanoids	72 <b>Hf</b> Hafnium 178.49	73 <b>Ta</b> Tantalum 180.94788	74 <b>W</b> Tungsten 183.84	75 <b>Re</b> Rhenium 186.207	76 <b>Os</b> Osmium 190.23	77 <b>Ir</b> Iridium 192.222	78 <b>Pt</b> Platinum 195.084	79 <b>Au</b> Gold 196.966569	80 <b>Hg</b> Mercury 200.592	81 <b>Tl</b> Thallium 204.38	82 <b>Pb</b> Lead 207.2	83 <b>Bi</b> Bismuth 208.98040	84 <b>Po</b> Polonium [209]	85 <b>At</b> Astatine [210]	86 <b>Rn</b> Radon [222]												
87 <b>Fr</b> Francium [223]	88 <b>Ra</b> Radium [226]	89 - 103 Actinoids	104 <b>Rf</b> Rutherfordium [261]	105 <b>Db</b> Dubnium [268]	106 <b>Sg</b> Seaborgium [266]	107 <b>Bh</b> Bohrium [270]	108 <b>Hs</b> Hassium [285]	109 <b>Mt</b> Meitnerium [276]	110 <b>Ds</b> Darmstadtium [285]	111 <b>Rg</b> Roentgenium [288]	112 <b>Cn</b> Copernicium [285]	113 <b>Nh</b> Nihonium [284]	114 <b>Fl</b> Flerovium [289]	115 <b>Mc</b> Moscovium [288]	116 <b>Lv</b> Livermorium [293]	117 <b>Ts</b> Tennessine [289]	118 <b>Og</b> Oganesson [294]												

57 <b>La</b> Lanthanum 138.90547	58 <b>Ce</b> Cerium 140.12	59 <b>Pr</b> Praseodymium 140.90768	60 <b>Nd</b> Neodymium 144.242	61 <b>Pm</b> Promethium [145]	62 <b>Sm</b> Samarium 150.36	63 <b>Eu</b> Europium 151.964	64 <b>Gd</b> Gadolinium 157.25	65 <b>Tb</b> Terbium 158.92535	66 <b>Dy</b> Dysprosium 162.500	67 <b>Ho</b> Holmium 164.93033	68 <b>Er</b> Erbium 167.258	69 <b>Tm</b> Thulium 168.93402	70 <b>Yb</b> Ytterbium 173.045	71 <b>Lu</b> Lutetium 174.967
89 <b>Ac</b> Actinium [227]	90 <b>Th</b> Thorium 232.0377	91 <b>Pa</b> Protactinium 231.03688	92 <b>U</b> Uranium 238.02891	93 <b>Np</b> Neptunium [237]	94 <b>Pu</b> Plutonium [244]	95 <b>Am</b> Americium [243]	96 <b>Cm</b> Curium [247]	97 <b>Bk</b> Berkelium [247]	98 <b>Cf</b> Californium [251]	99 <b>Es</b> Einsteinium [252]	100 <b>Fm</b> Fermium [257]	101 <b>Md</b> Mendelevium [258]	102 <b>No</b> Nobelium [259]	103 <b>Lr</b> Lawrencium [260]





Instagram: Sneppen et Albert