

$$t_{ss} \sim \frac{5 \times 10^{10} \text{ yr}}{\ln \Lambda} \left(\frac{r_0}{1 \text{ kpc}} \right)^2 \left(\frac{v_c}{200 \text{ km/s}} \right) \left(\frac{M}{10^6 M_\odot} \right)^{-1}$$



Large and Small Magellanic Clouds

$$t_{ss} \sim \frac{5 \times 10^{10} \text{ yr}}{\ln \Lambda} \left(\frac{r_0}{1 \text{ kpc}} \right)^2 \left(\frac{v_c}{200 \text{ km/s}} \right) \left(\frac{M}{10^6 M_\odot} \right)^{-1}$$

LMC: $r_0 = 49 \text{ kpc}$, $v_c = 290 \text{ km/s}$, $M = 2 \times 10^{10} M_\odot$, $\Lambda \sim 50$

$$\Rightarrow t_{ss} = 2.5 \text{ Gyr}$$

SMC: $r_0 = 57 \text{ kpc}$, $v_c = 240 \text{ km/s}$, $M = 2.5 \times 10^9 M_\odot$, $\Lambda \sim 300$

$$\Rightarrow t_{ss} = 1.6 \text{ Gyr}$$



M51

$$t_{ss} \sim \frac{5 \times 10^{10} \text{ yr}}{\ln \Lambda} \left(\frac{r_0}{1 \text{ kpc}} \right)^2 \left(\frac{v_c}{200 \text{ km/s}} \right) \left(\frac{M}{10^6 M_\odot} \right)^{-1}$$

LMC: $r_0 = 49 \text{ kpc}$, $v_c = 290 \text{ km/s}$, $M = 2 \times 10^{10} M_\odot$, $\Lambda \sim 50$
 $\Rightarrow t_{ss} = 2.5 \text{ Gyr}$

SMC: $r_0 = 57 \text{ kpc}$, $v_c = 240 \text{ km/s}$, $M = 2.5 \times 10^9 M_\odot$, $\Lambda \sim 300$
 $\Rightarrow t_{ss} = 1.6 \text{ Gyr}$

M51: $r_0 = 10 \text{ kpc}$, $v_c = 200 \text{ km/s}$, $M = 5 \times 10^{10} M_\odot$, $\Lambda \sim 10$
 $\Rightarrow t_{ss} = 50 \text{ Myr}$



M81/82



M82

$$t_{ss} \sim \frac{5 \times 10^{10} \text{ yr}}{\ln \Lambda} \left(\frac{r_0}{1 \text{ kpc}} \right)^2 \left(\frac{v_c}{200 \text{ km/s}} \right) \left(\frac{M}{10^6 M_\odot} \right)^{-1}$$

LMC: $r_0 = 49 \text{ kpc}$, $v_c = 290 \text{ km/s}$, $M = 2 \times 10^{10} M_\odot$, $\Lambda \sim 50$
 $\Rightarrow t_{ss} = 2.5 \text{ Gyr}$

SMC: $r_0 = 57 \text{ kpc}$, $v_c = 240 \text{ km/s}$, $M = 2.5 \times 10^9 M_\odot$, $\Lambda \sim 300$
 $\Rightarrow t_{ss} = 1.6 \text{ Gyr}$

M51: $r_0 = 10 \text{ kpc}$, $v_c = 200 \text{ km/s}$, $M = 5 \times 10^{10} M_\odot$, $\Lambda \sim 10$
 $\Rightarrow t_{ss} = 50 \text{ Myr}$

M82: $r_0 = 40 \text{ kpc}$, $v_c = 200 \text{ km/s}$, $M = 5 \times 10^9 M_\odot$, $\Lambda \sim 10$
 $\Rightarrow t_{ss} = 7 \text{ Gyr}$

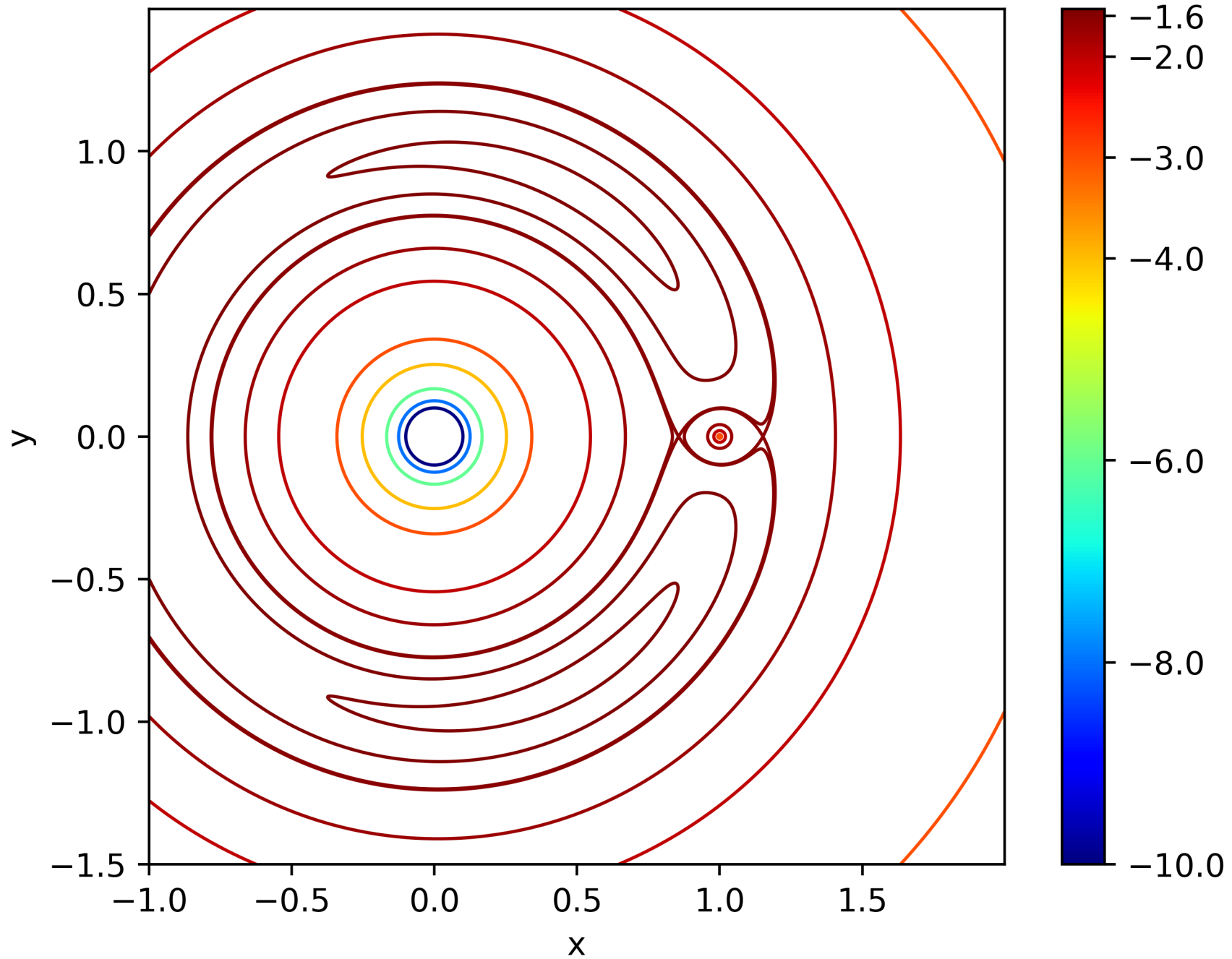


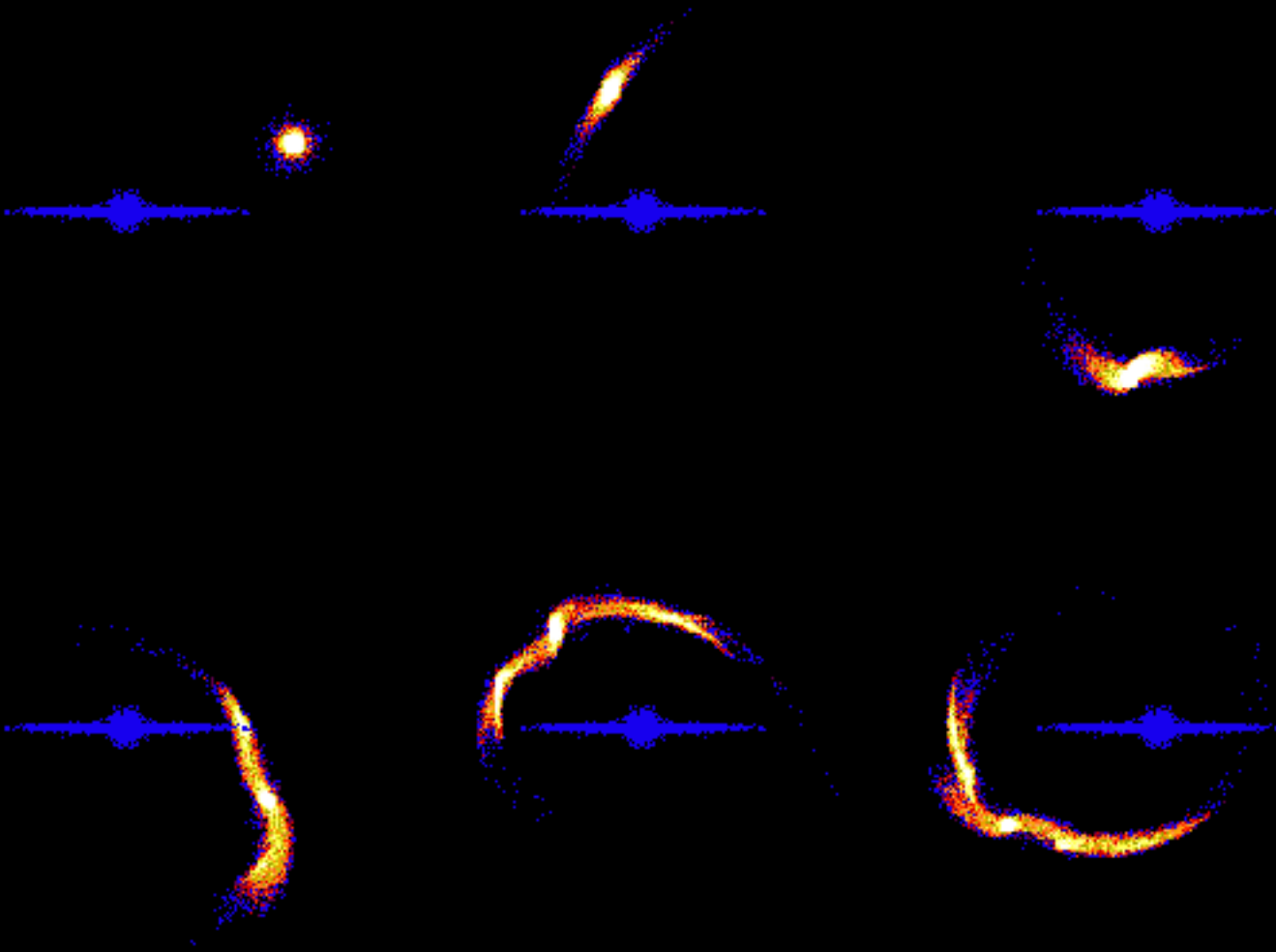
Radio Galaxy MRC 1138-262 • **The Spiderweb Galaxy**
Hubble Space Telescope • Advanced Camera for Surveys

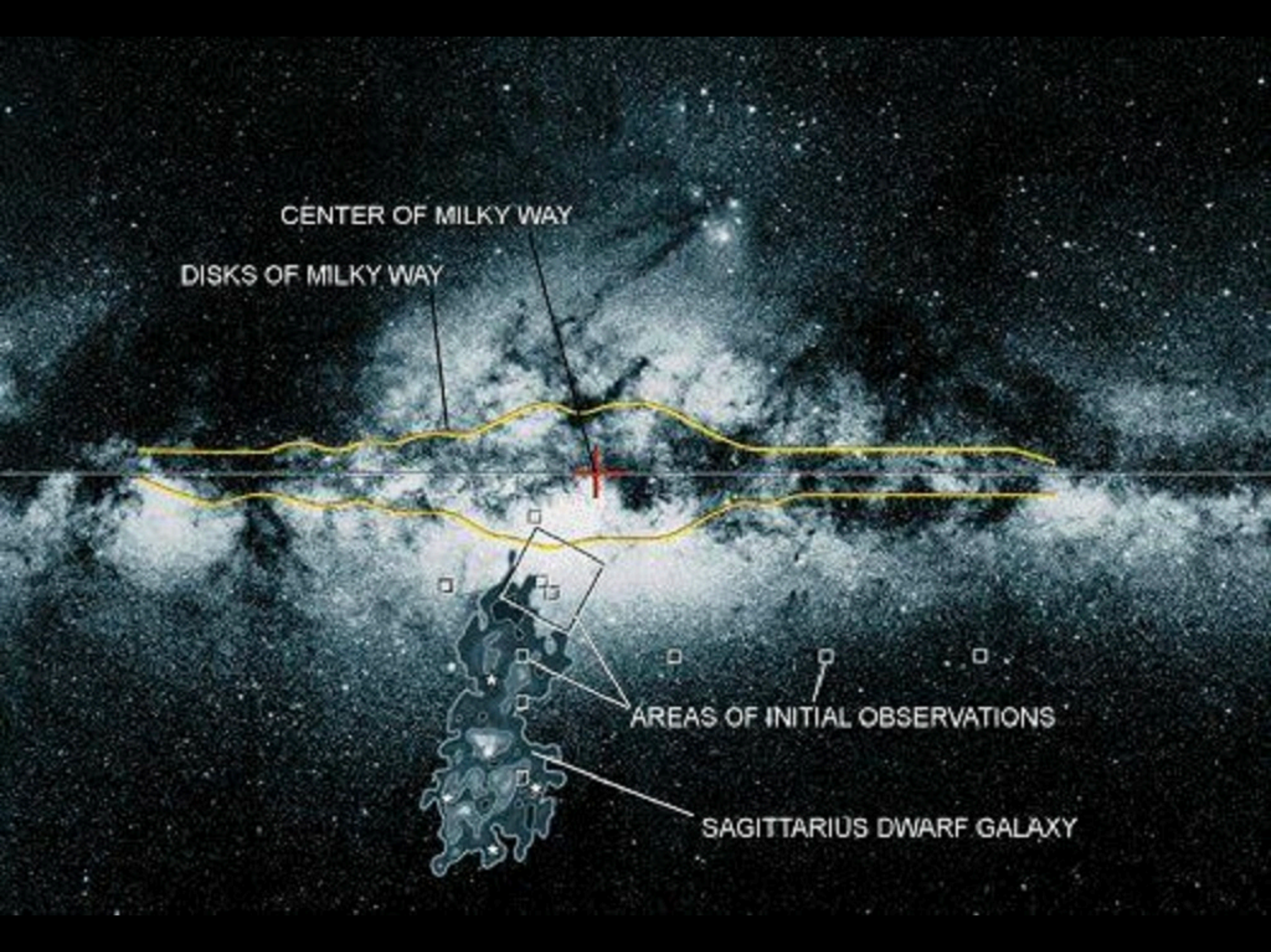


Virgo cluster

Equipotentials, $M = 1.000$, $m = 0.010$, $G = 1$





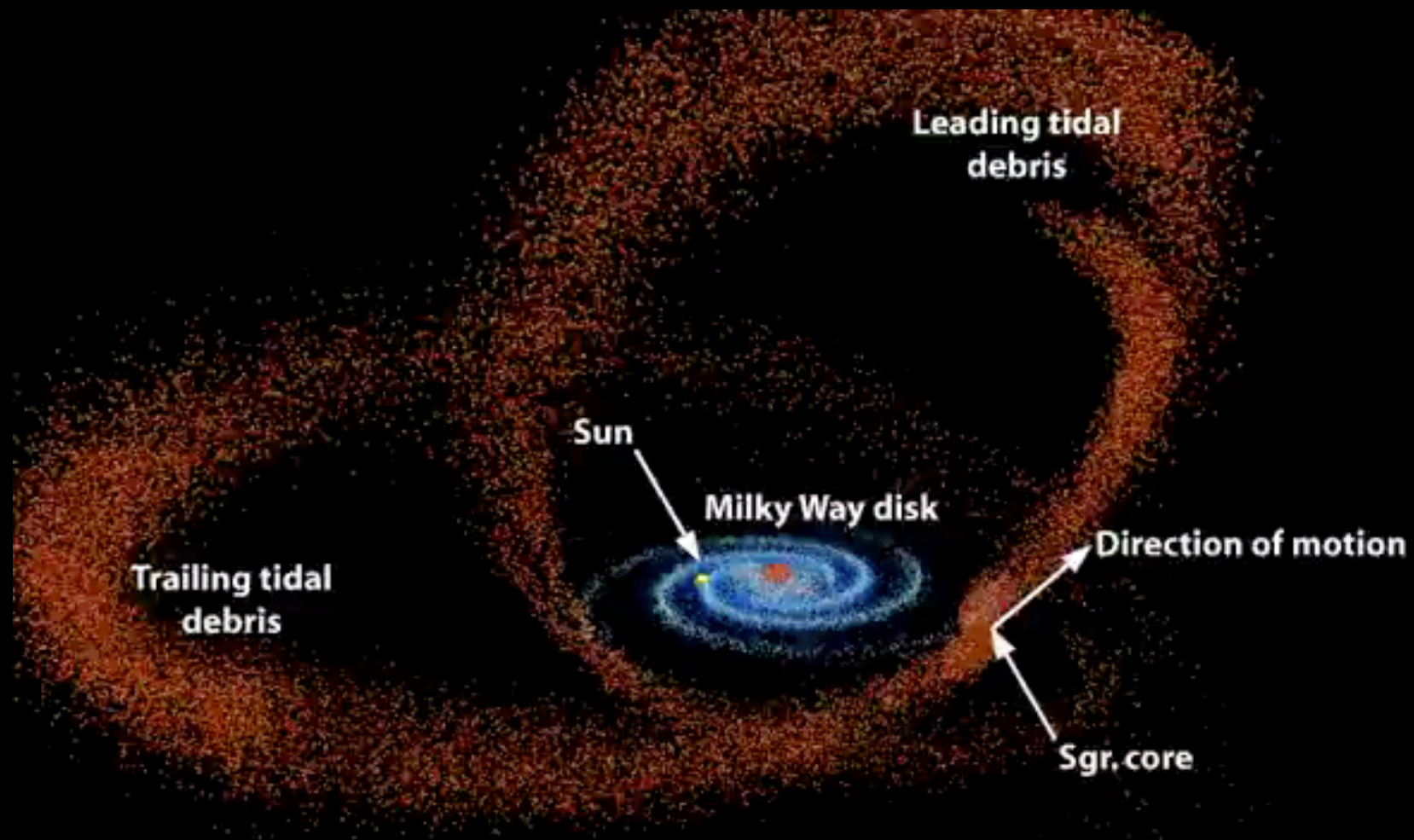


CENTER OF MILKY WAY

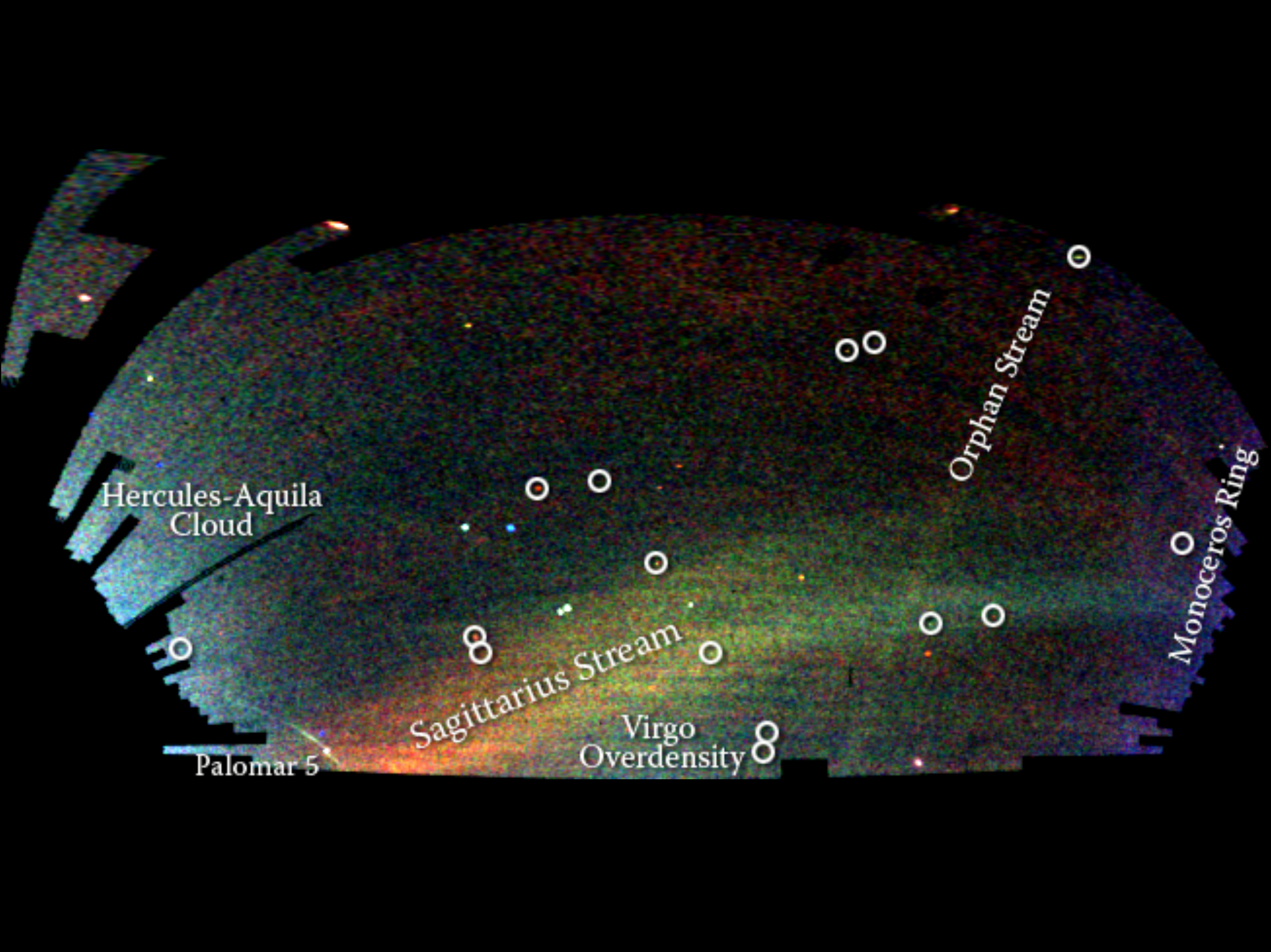
DISKS OF MILKY WAY

AREAS OF INITIAL OBSERVATIONS

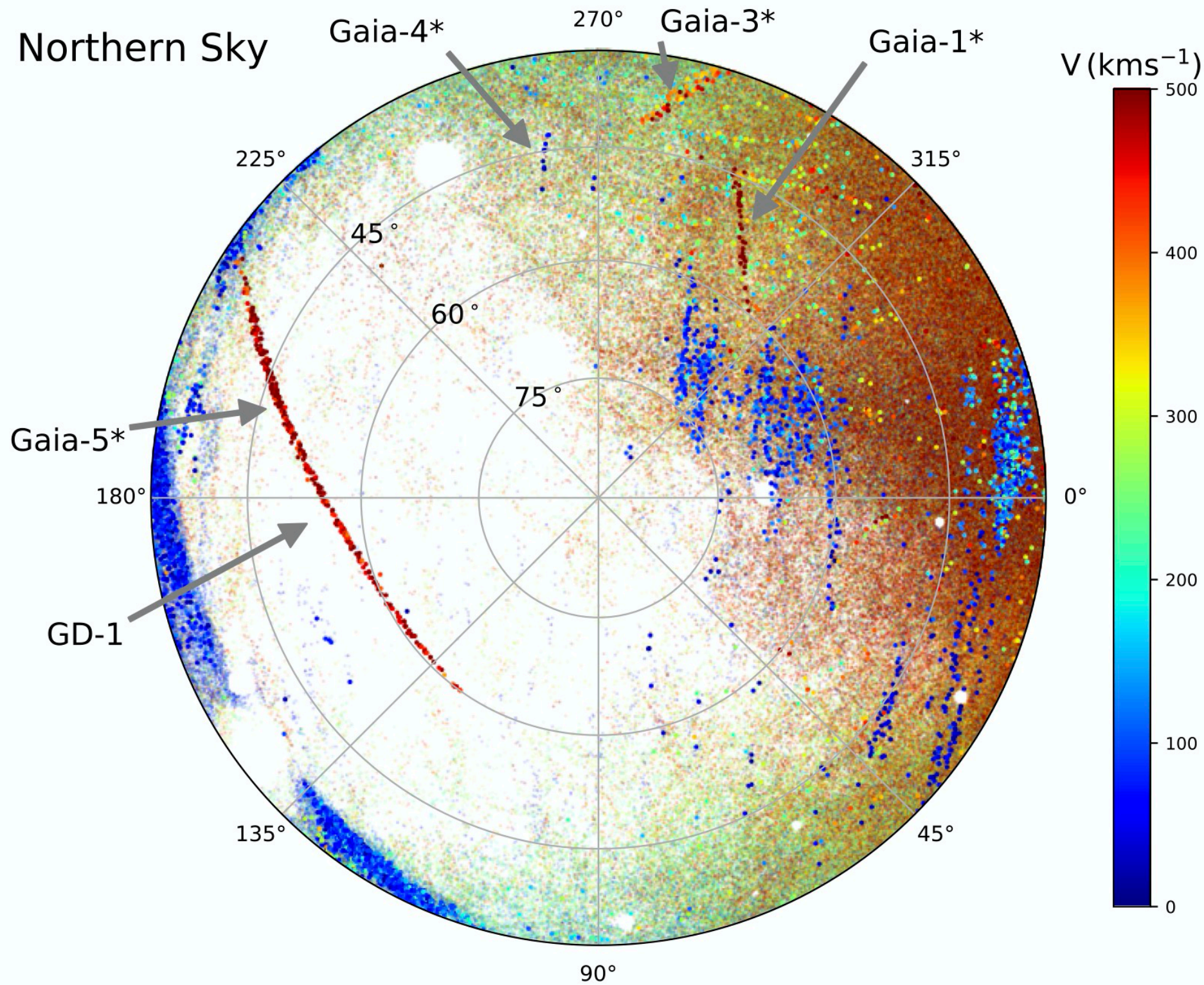
SAGITTARIUS DWARF GALAXY



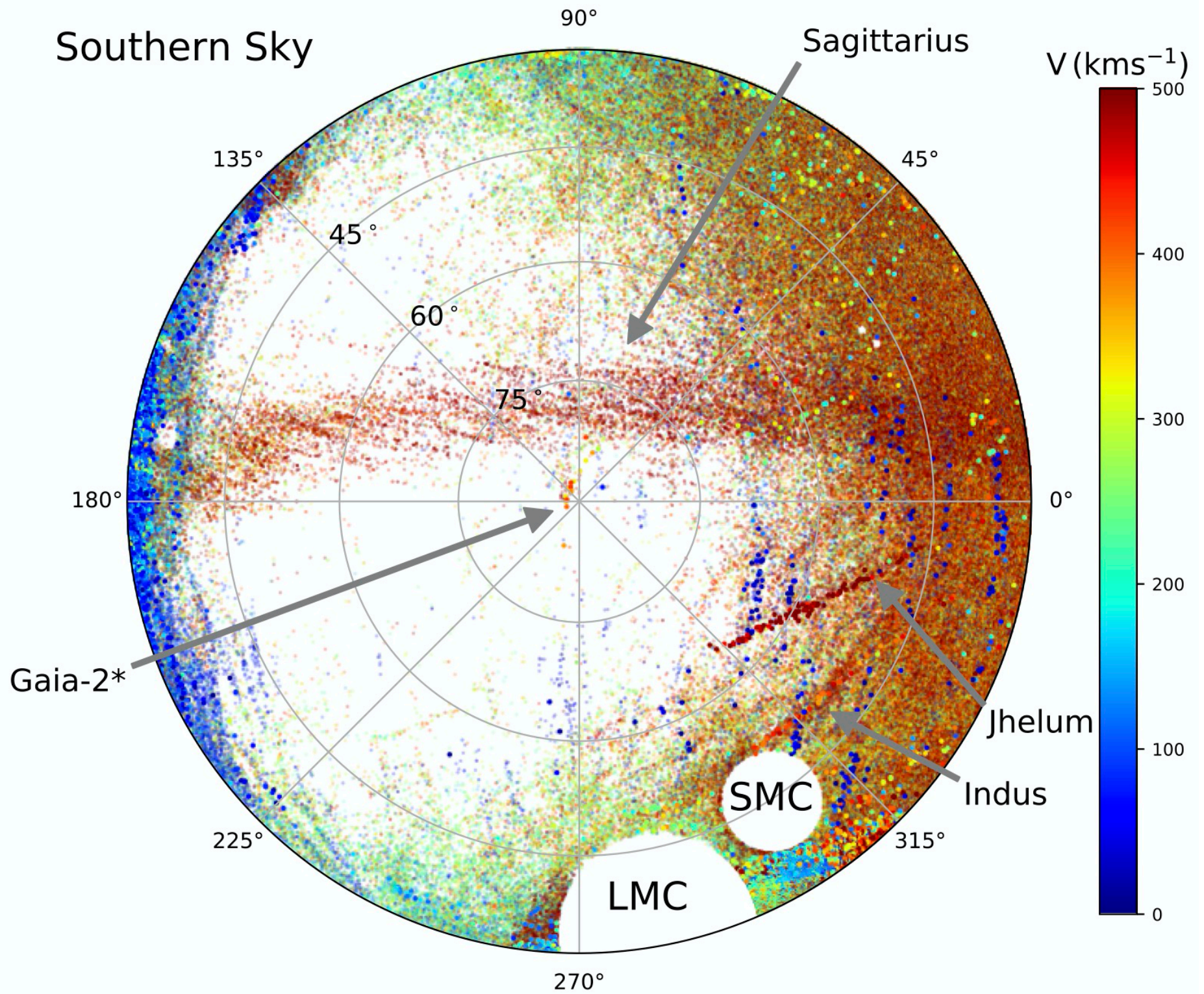
David R. Law
UCLA



Northern Sky

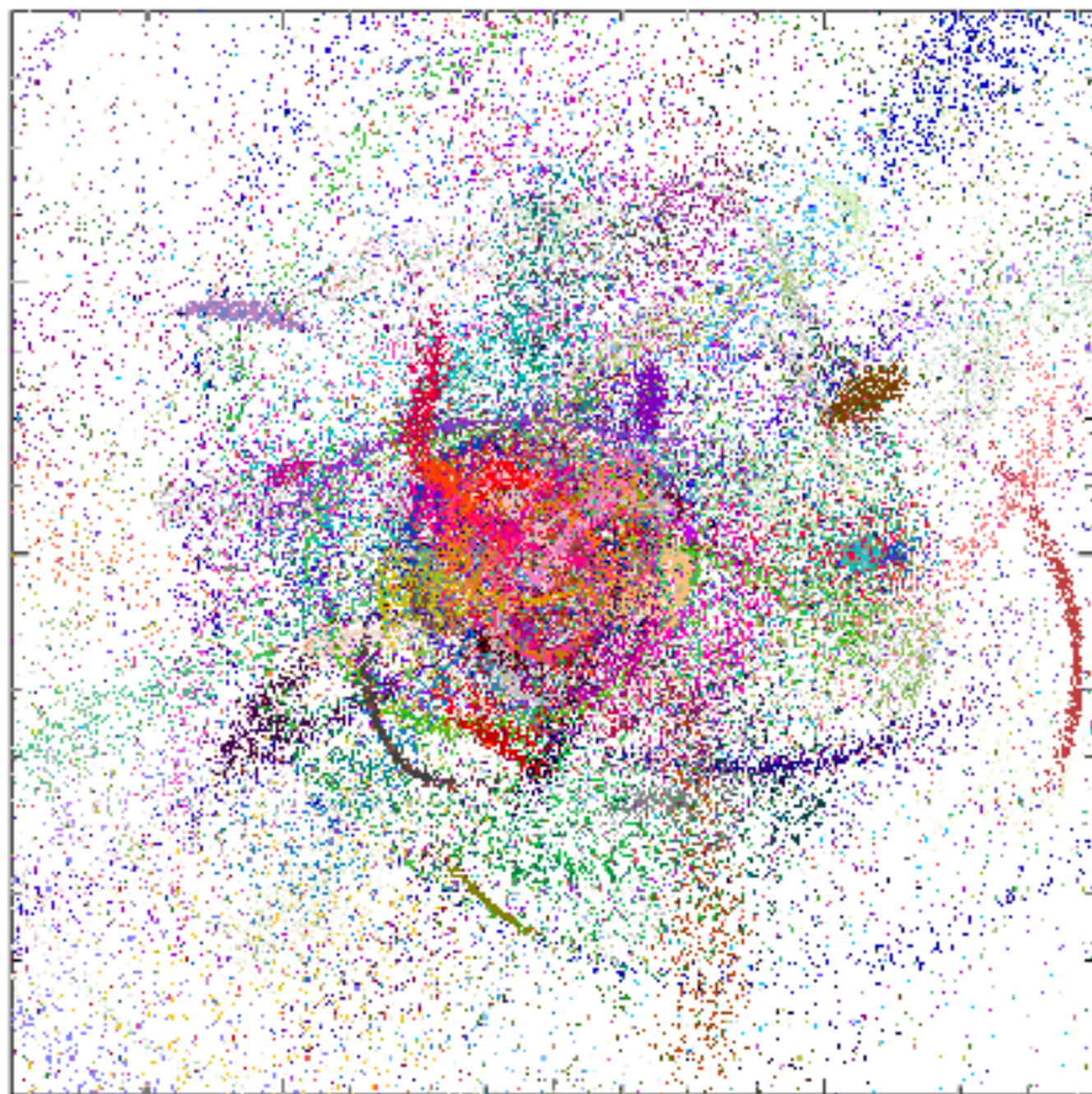


Southern Sky



Tidal streams from shredded companion

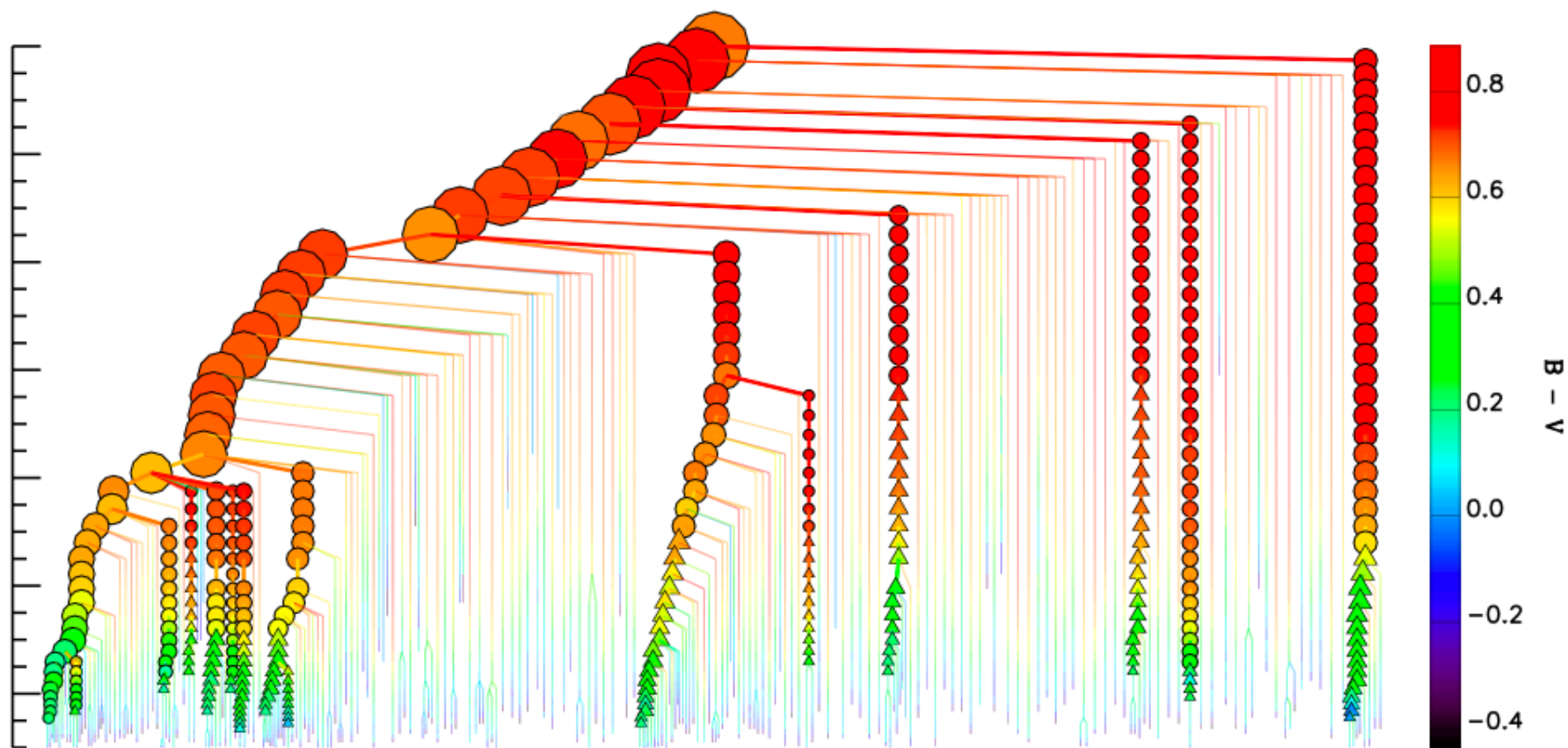




Present
Day

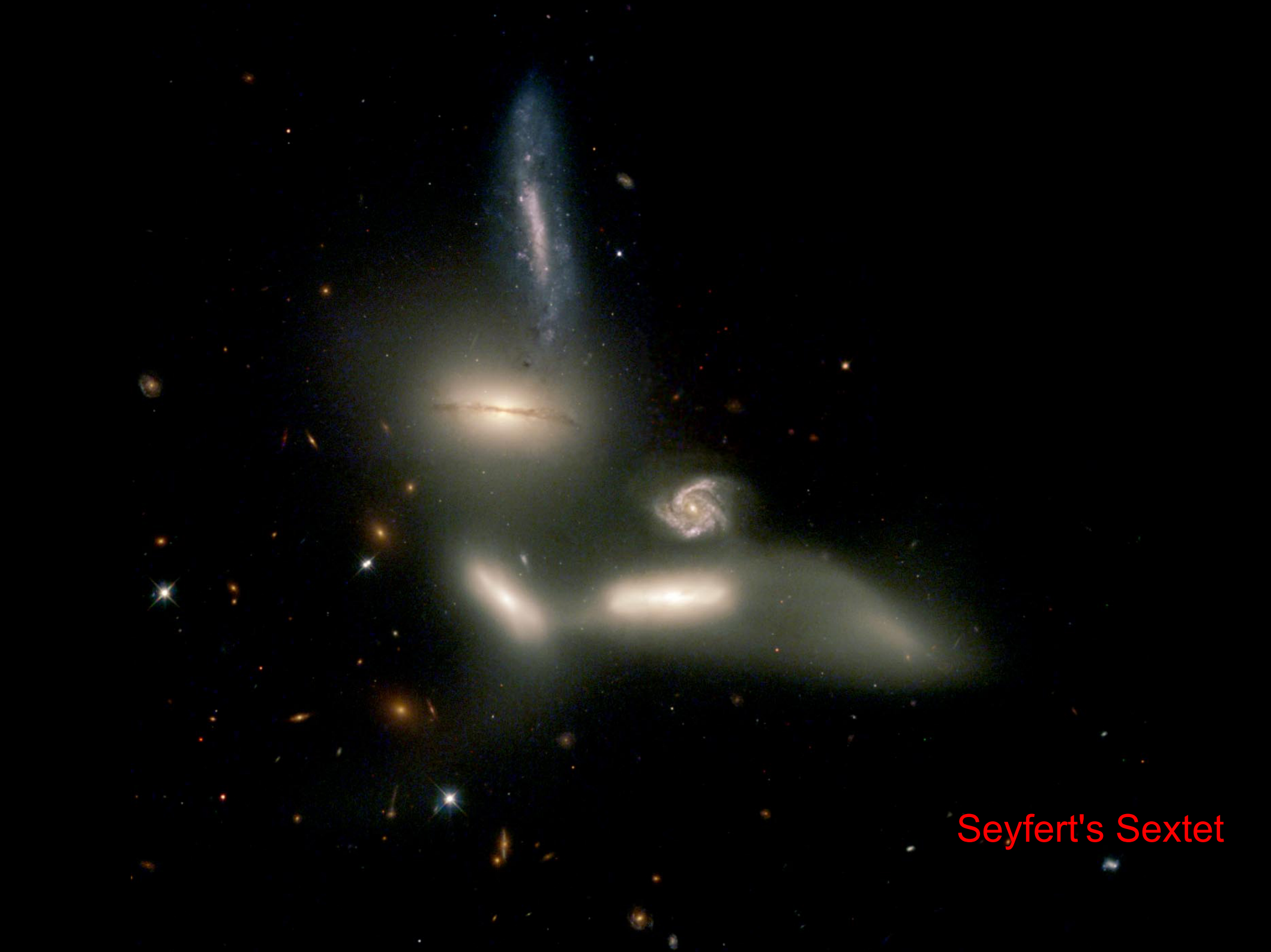
lookback time (Gyr)

Big
Bang

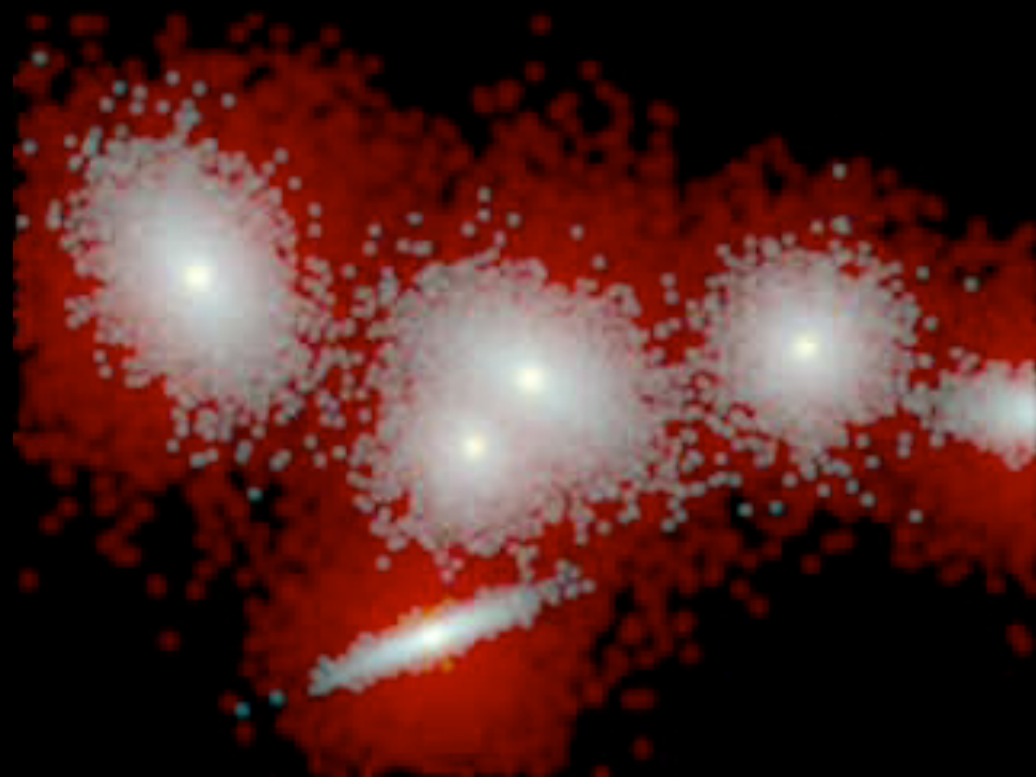
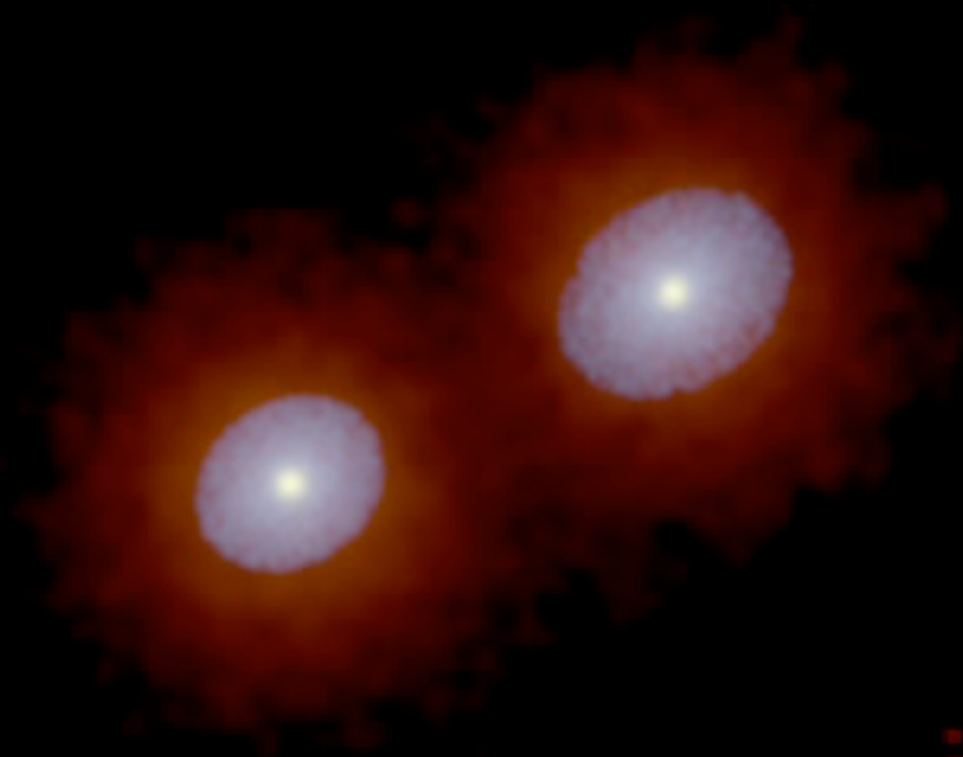




Antennae

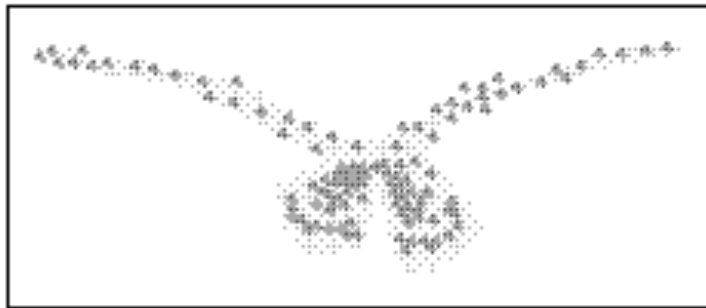
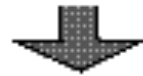
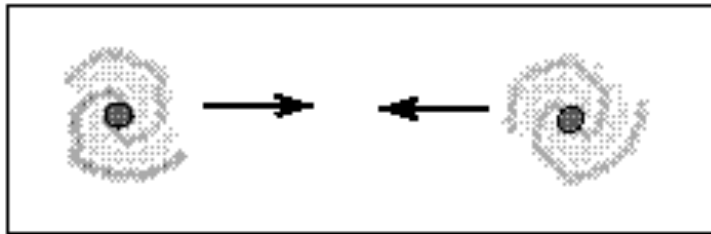


Seyfert's Sextet

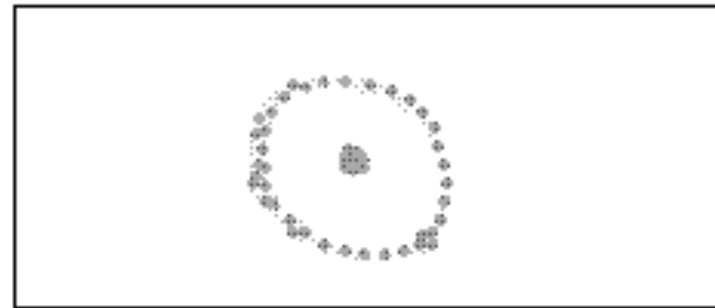
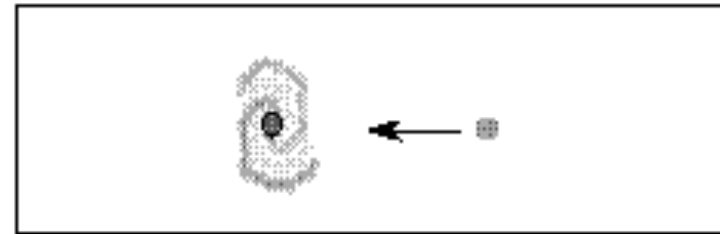




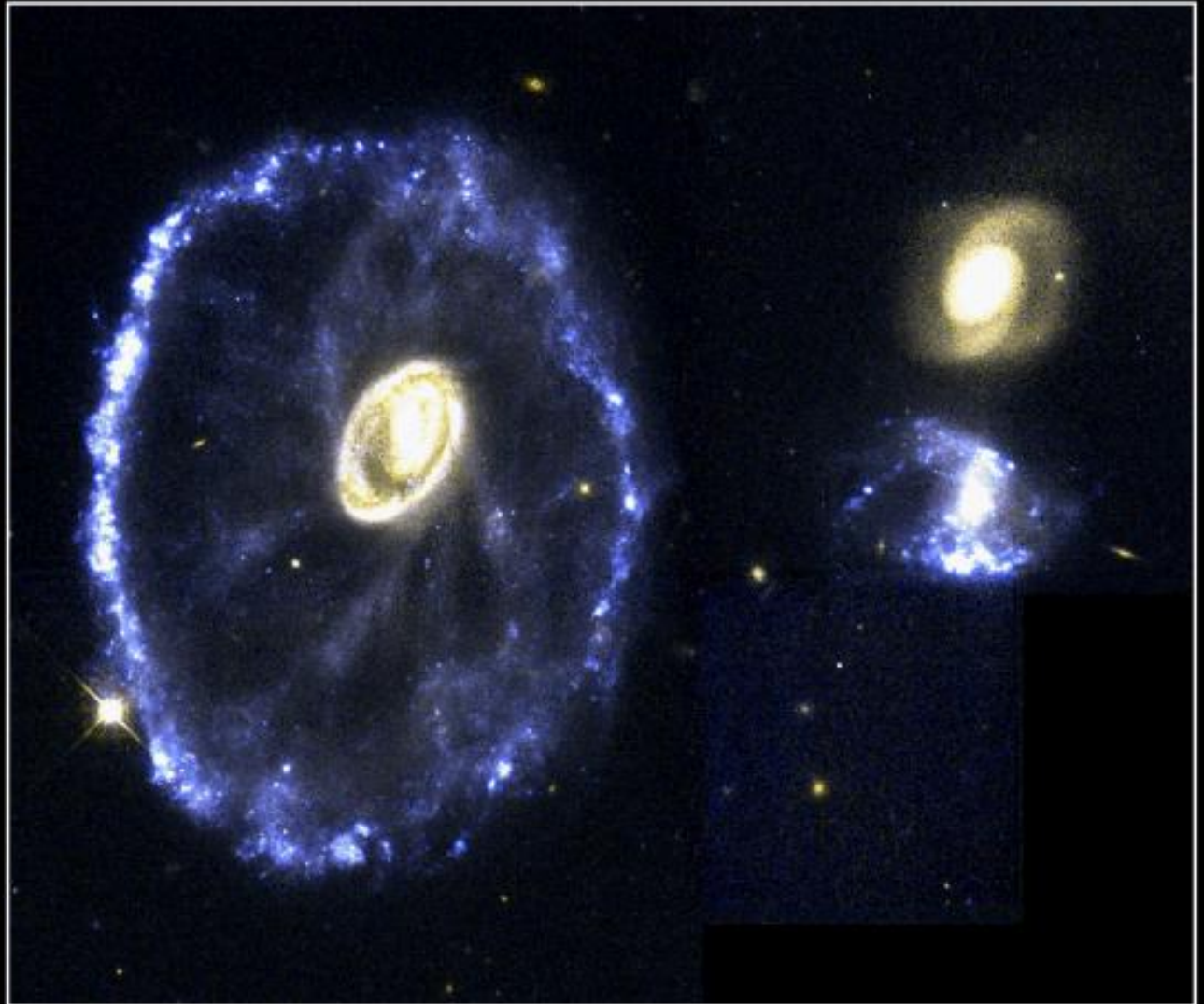
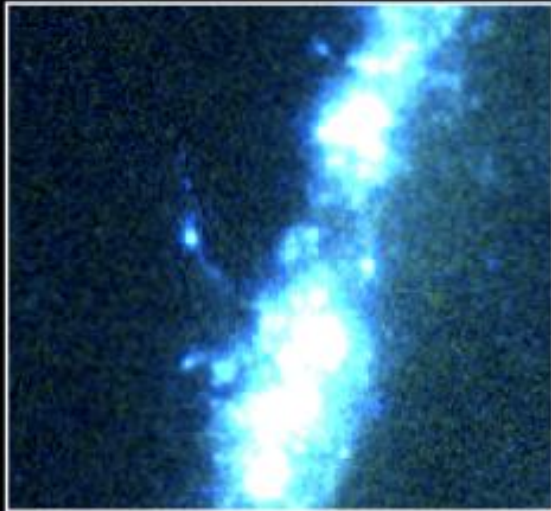
Barnes 1990



Two galaxies collide to
produce long “tails”



Small galaxy hits a large disk galaxy
head-on to produce a ring galaxy.

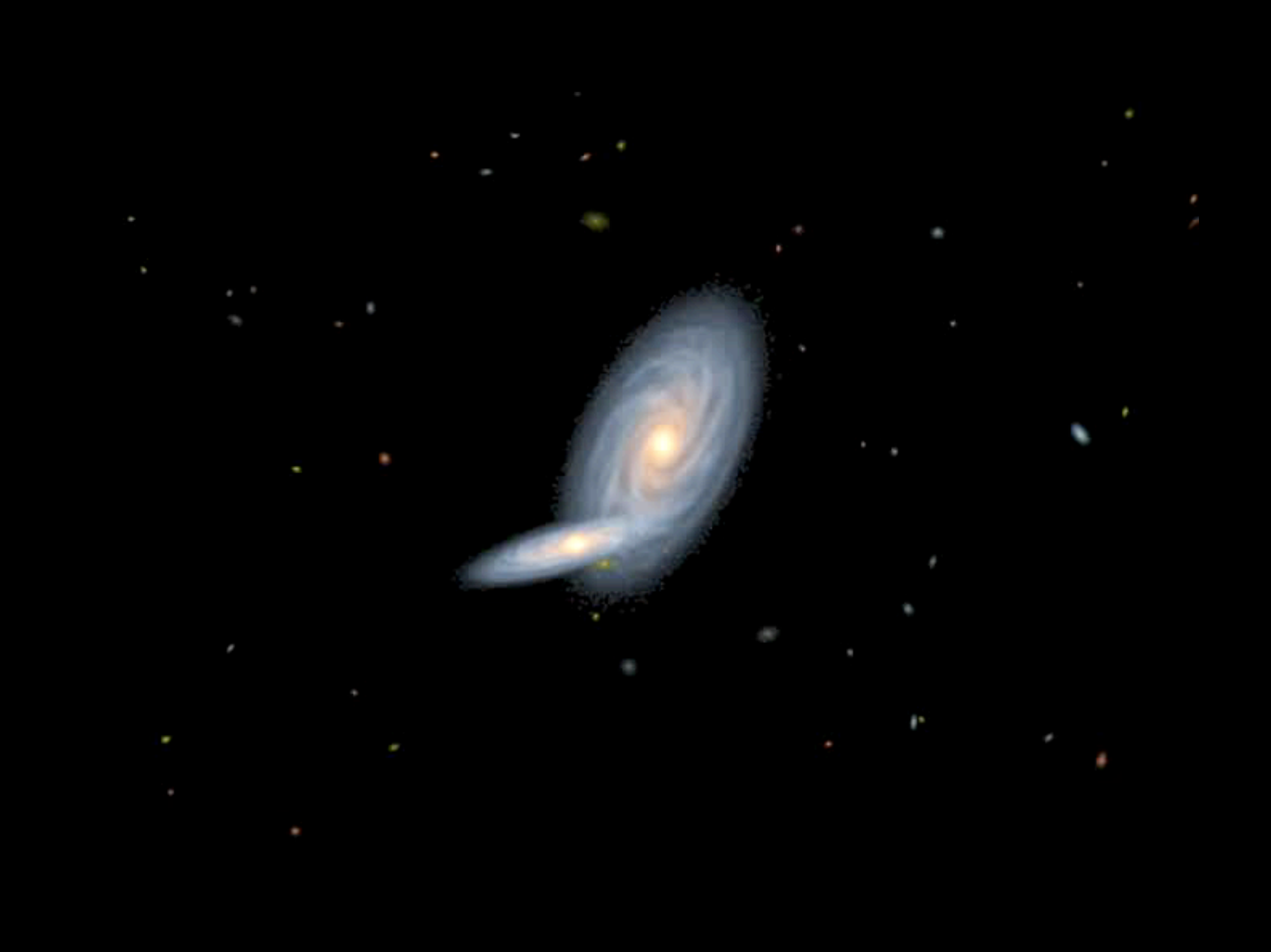


Cartwheel Galaxy

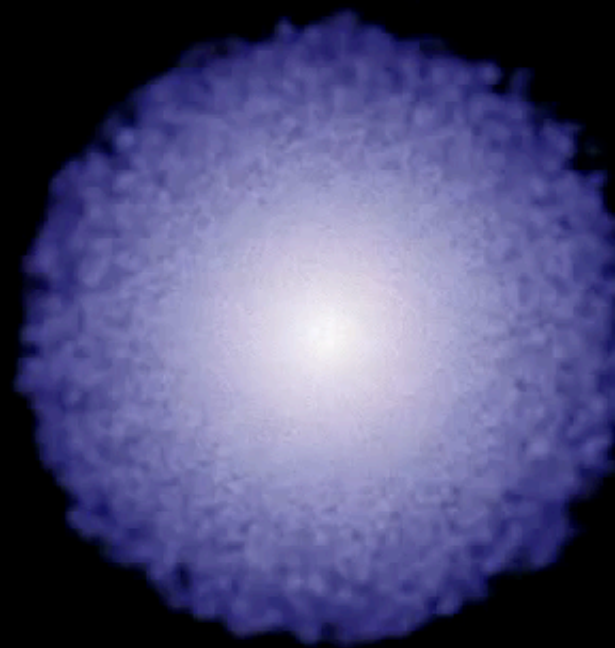
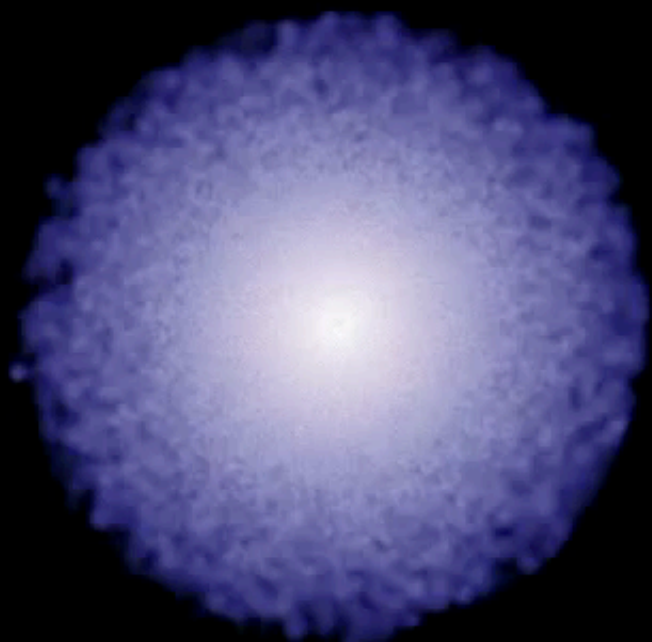
PR95-02 • ST Scl OPO • January 1995 • K. Borne (ST Scl), NASA

HST • WFPC2

12/23/94 zgl



$T = 0 \text{ Myr}$



10 kpc/h

