Local Group of Galaxy, Dynamical mass of local group

- The Local Group contains roughly three dozen galaxies within a sphere about a megaparsec in radius, centered between the Milky Way and our nearest large neighbor, the Andromeda galaxy M31.
- The below table shows the major candidates of this group.

Galaxy	*Type*	d (kpc)	L_V ($10^7 L_\odot$)	$V_r(\odot)$ (km s^{-1})	l (deg)	b (deg)	$\mathcal{M}$(HI) ($10^6 \mathcal{M}_\odot$)
M31 (NGC 224)	Sb	770	2700	−300	121	−22	5700
Milky Way	Sbc	8	1500	−10	0	0	4000
M33 (NGC 598)	Sc	850	550	−183	134	−31	1500
Large MC	SBm	50	200	274	280	−33	500
Small MC	Irr	63	55	148	303	−44	400
NGC 205	dE	830	40	−244	121	−21	0.4
M32 (NGC 221)	E2	770	40	−205	121	−22	<2.5[c]
NGC 6822	dIrr	500	10	−56	25	−18	140[c]
IC 10	dIrr	660	16	−344	119	−3	100
NGC 185	dE	620	13	−202	121	−15	0.1
NGC 147	dE	760	12	−193	120	−14	None
Sagittarius	dSph	30	8	170	6	−14	None
IC 1613 (DDO 8)	dIrr	715	6	−233	130	−61	60
WLM (DDO 221)	dIrr	950	5	−120	76	−74	60
Pegasus (DDO 216)	dIrr/dSph	760	1	−182	95	−44	3
Fornax	dSph	140	1.5	53	237	−66	<0.7
Sagittarius DIG	dIrr	1050	0.7	−78	21	−16	9
And I	dSph	790	0.5	−380	122	−25	None
Leo I (DDO 74)	dSph	270	0.5	285	226	49	None
And VII/Cas dSph	dSph	760	0.5	−307	110	−10	
Leo A (DDO 69)	dIrr	800	0.4	20	197	52	8
And VI/Peg dSph	dSph	775	0.3	−354	106	−36	
And II	dSph	680	0.2	−188	129	−29	
Sculptor	dSph	88	0.2	107	288	−83	≲0.1[c]
LGS3 (Pisces)	dIrr/dSph	620	0.13	−286	127	−41	0.2
Aquarius (DDO 210)	dIrr/dSph	950	0.1	−137	34	−31	3
And III	dSph	760	0.1	−355	119	−26	None
Phoenix	dIrr/dSph	405	0.09	56	272	−69	~0.2
Cetus	dSph	775	0.09		101	−73	
Leo II (DDO 93)	dSph	205	0.06	76	220	67	None
Tucana	dSph	870	0.06		323	−47	None
Sextans	dSph	85	0.05	225	244	42	None
Draco (DDO 216)	dSph	80	0.05	−293	86	35	None
Carina	dSph	95	0.04	223	260	−22	None
And V	dSph	810	0.04	−403	126	−15	
Ursa Minor	dSph	70	0.03	−247	105	45	None
And IX	dSph	790	0.02	−210	123	−20	
Ursa Major	dSph	~100	0.004	−52	160	54	

Figure 1: Galaxies of the Local Group within 1 Mpc of the Sun: the Milky Way and its satellites are listed in boldface; M31 and its companions are listed in italics

- Few details about the local group
  1. The three major contributors for luminosity are spirals(Milky Way,M31,M33) and hence accounts for about 90% of the total luminosity.
  2. The above three galaxy also accounts for the major part of mass distribution of the group.

3. M32 is the only elliptical galaxy present and rest are irregulars

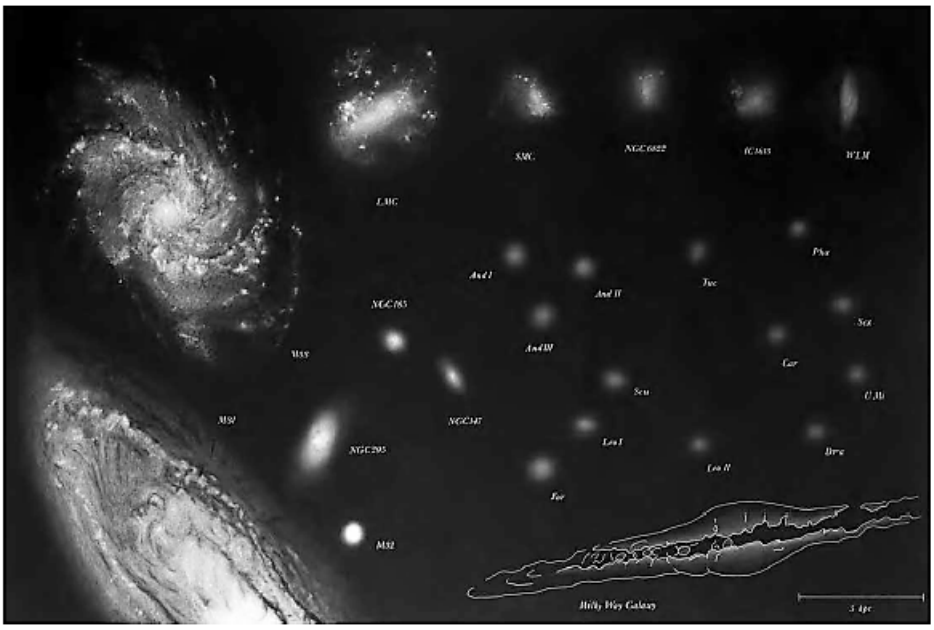

Figure 2: The Galaxies of local group

- ***Dynamical mass of the local group***
- Let suppose two galaxies at a distance 'r' from each other, the the energy equation for this system can be written as ,

$$\frac{v(t)^2}{2} = \frac{GM}{r} - \frac{GM}{r_{max}} \tag{1}$$

Where:

M is total mass of MW and M31
'r' is time dependent separation
'r_{max}' is the maximum separation possible between these two
'v(t)' is the relative velocity between the two galaxies

$$v(t) = (\frac{dr}{dt})$$

$$\frac{dr}{2dt}^2 = GM(\frac{1}{r} - \frac{1}{r_{max}}) \tag{2}$$

- $at, t = 0, v = 0$

$$t_{max} = \int_0^{\tau_{max}} dt \tag{3}$$

Where : t_{max} is the time to reach maximum separation between two galaxies

- So, writing the equation fir t_{max} from above equation,

$$t_(max) = \int_{r_{max}}^{0} \frac{dt}{\sqrt{2GM}\sqrt{\frac{1}{r} - \frac{1}{r_{max}}}} \tag{4}$$

$$t_{max} = \frac{1}{2\sqrt{2GM}} \pi r_{max}^3 \tag{5}$$

- Lets consider that the time taken by two galaxy to move away from each other and then after the maximum separation they start coming back towards each other equals $2t_{max}$.

$$2t_{max} = t_o + \frac{D}{v} \tag{6}$$

Where:

t_{max} is the time taken by galaxies to start moving from a point , move away and again come back to the same point.
t_o is the current age of Universe.
D is the distance between two galaxies.
v is the relative velocity of the galaxies.

- $t_o = 14Gyr$, $D = 770kpc$, $v = 120km/s$, we get $t_{max} = 6.2Gyr$, and also taking value of $r_{max} = 770kpc$ the value for dynamical mass calculated to be $M = 3 * 10^{12} M_o$.
- This mass is about 5% of the total mass , rest of the mass are supposed as Dark matter.