

우주와 생명 제 8강  
우주의 팽창

SEOUL NATIONAL UNIVERSITY

Proc. Nat. Acad. Sci. (1929)

## 외계 성운에서 거리와 시선 속도의 관계 A Relation between Distance and Radial Velocity among Extra-Galactic Nebulae



<출처>  
[http://2.bp.blogspot.com/\\_xYK0EVHYM8Q/S9i38lyfS3I/AAAAAAAUQ/UKOlvCSlqK8/s320/Andromeda+Galaxy+1.jpg](http://2.bp.blogspot.com/_xYK0EVHYM8Q/S9i38lyfS3I/AAAAAAAUQ/UKOlvCSlqK8/s320/Andromeda+Galaxy+1.jpg)

에드윈 허블  
Edwin Hubble



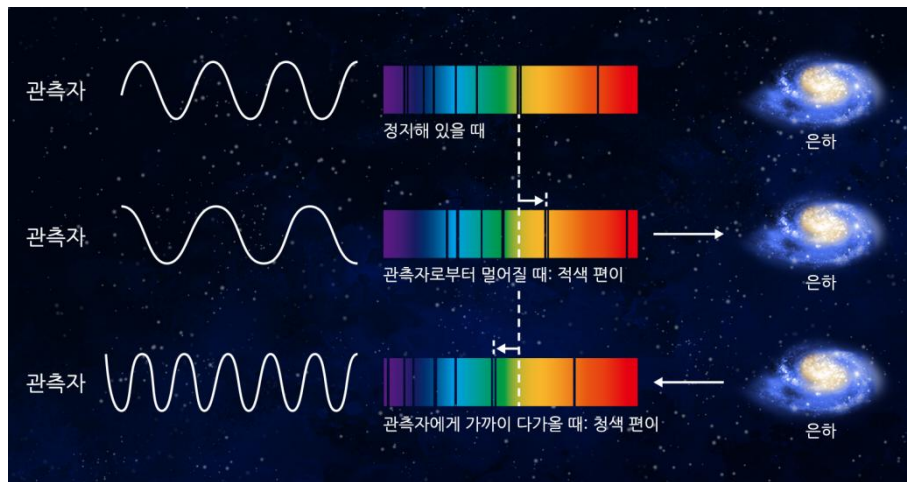
<출처>  
[http://astronomylinks.wikispaces.com/file/view/pic\\_2.jpg/327424970/pic\\_2.jpg](http://astronomylinks.wikispaces.com/file/view/pic_2.jpg/327424970/pic_2.jpg)

# 8-1 리비트의 별(Leavitt's Stars)

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우리은하 밖의 성운에 대한 태양의 상대 운동을 측정하면 수백 킬로미터 정도의 다른 값들을 가지는  $K$  항이 얻어진다.

Determinations of the motion of the sun with respect to the extra-galactic nebulae have involved a  $K$  term of several hundred kilometers which appears to be variable.



## 8-1 리비트의 별(Leavitt's Stars)

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외계 성운의 거리는 종류를 알 수 있는 별에 대해 절대광도의 기준을 어떻게 적용하느냐에 달려있다. 그런 별에는 세페이드 변광성, 신성, 그리고 방출 성운에 관련된 청색 별 등이 있다.

Distances of extra-galactic nebulae depend ultimately upon the application of absolute-luminosity criteria to involved stars whose types can be recognized. These include Cepheid variables, novae, and blue stars involved in emission nebulosity.

# 8-1 리비트의 별(Leavitt's Stars)

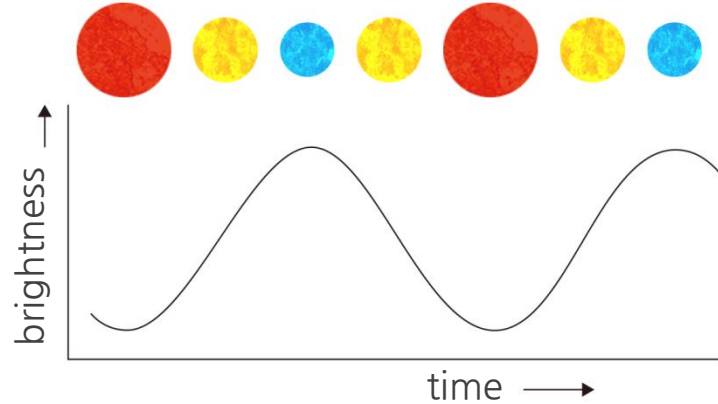
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<출처>  
[http://3.bp.blogspot.com/-PMM3TLx4gzc/T6l3DdqOxal/AAAAAAAKT8/nEttL7lUsEU/s400/Leavitt\\_henrietta\\_b1.jpg](http://3.bp.blogspot.com/-PMM3TLx4gzc/T6l3DdqOxal/AAAAAAAKT8/nEttL7lUsEU/s400/Leavitt_henrietta_b1.jpg)

리비트 Henrietta Leavitt  
(1868-1921)

## Variable Star



“the brighter variables have the longer periods” (1908)

# 8-1 리비트의 별(Leavitt's Stars)

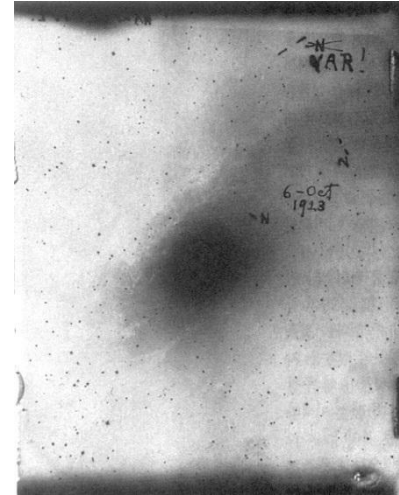
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월슨 산 천문대의  
100 인치 망원경을 사용해서  
은하를 관찰하는 허블

<출처>  
[http://3.bp.blogspot.com/-zucxIUQXdU8/Th1qfYNYKkl/AAAAAAAAACc8/h1A4sC\\_fUDc/s400/hubble\\_mtwilson.jpg](http://3.bp.blogspot.com/-zucxIUQXdU8/Th1qfYNYKkl/AAAAAAAAACc8/h1A4sC_fUDc/s400/hubble_mtwilson.jpg)

## Andromeda 250만 광년



허블이 1923년에  
안드로메다 성운에서 발견한  
세페이드 변광성

<출처>  
<http://www.aip.org/history/cosmology/ideas/images-ideas/Messier-31.jpg>

## 8-2 허블의 법칙(Hubble's Law)

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46개 외계 성운에 대한  
시선 속도가 알려져  
있는데, 각각의 거리가  
추정된 것은 24개 뿐이다.  
여러 개의 별들을 상세히  
조사해서 얻은 처음  
7개의 거리는 가장 믿을  
만하다.



<출처>

[http://farm9.staticflickr.com/8374/8579532405\\_13d272476d\\_z.jpg](http://farm9.staticflickr.com/8374/8579532405_13d272476d_z.jpg)

소대 마젤란 성운

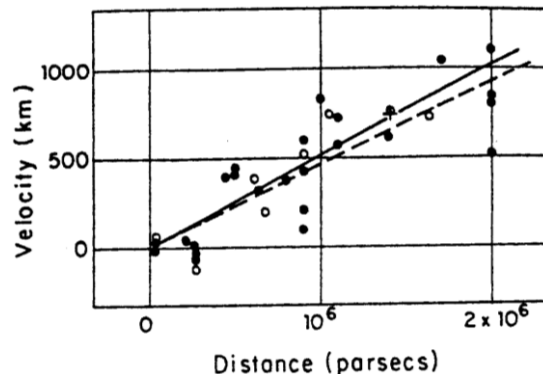
Radial velocities of 46  
extra-galactic nebulae  
are now available, but  
individual distances are  
estimated for only 24.

The first seven distances  
are the most reliable,  
depending upon  
extensive investigations  
of many stars involved.

## 8-2 허블의 법칙(Hubble's Law)

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이처럼 자료가 부족하고  
분포도 좋지 않은 데  
비해서 결과는 상당히  
확실하다.



EDWIN HUBBL, A RELATION BETWEEN DISTANCE  
AND RADIAL VELOCITY  
AMONG EXTRA-GALACTIC NEBULAE, January 17,  
1929.

For such scanty material,  
so poorly distributed,  
the results are  
Fairly definite.



## 8-2 허블의 법칙(Hubble's Law)

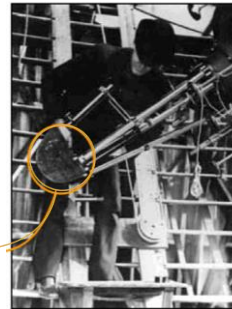
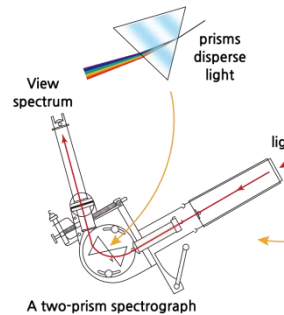
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이 결과는 속도가 이미 알려져 있는 성운들에 대해서 속도와 거리 사이에 대략적인 비례 관계가 있는 것을 확실하게 보여준다.



<출처>  
[http://upload.wikimedia.org/wikipedia/commons/thumb/a/a7/V.M.\\_Slipher.gif/220px-V.M.\\_Slipher.gif](http://upload.wikimedia.org/wikipedia/commons/thumb/a/a7/V.M._Slipher.gif/220px-V.M._Slipher.gif)

슬라이퍼  
Vesto Slipher



Vesto Slipher & spectrograph

The results establish a roughly linear relation between velocities and distances among nebulae for which velocities have been previously published, and the relation appears to dominate the distribution of velocities.

The Radial Velocity of the Andromeda Nebula (1913)

## 8-3 밀튼 휴메이슨(Milton Humason)

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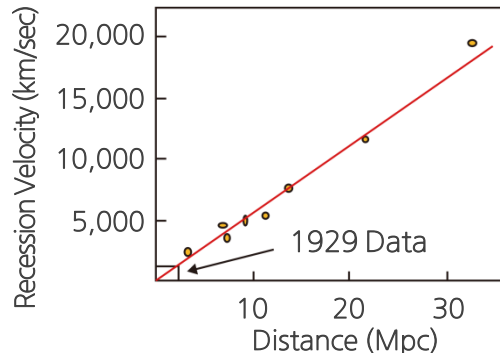
이 점을 더 큰 스케일에서 조사하기 위해 윌슨 산의 휴메이슨은 제대로 관찰할 수 있는 가장 먼 성운들의 속도를 측정하는 프로그램에 착수했다.



<출처>  
[http://1.bp.blogspot.com/RhGWCK\\_jwRU/UGqYNSe6JUI/AAAAAAAAAFU/Kc5j8Y8azTo/s1600/Milton+Humason.jpeg](http://1.bp.blogspot.com/RhGWCK_jwRU/UGqYNSe6JUI/AAAAAAAAAFU/Kc5j8Y8azTo/s1600/Milton+Humason.jpeg)

휴메이슨  
Milton Humason

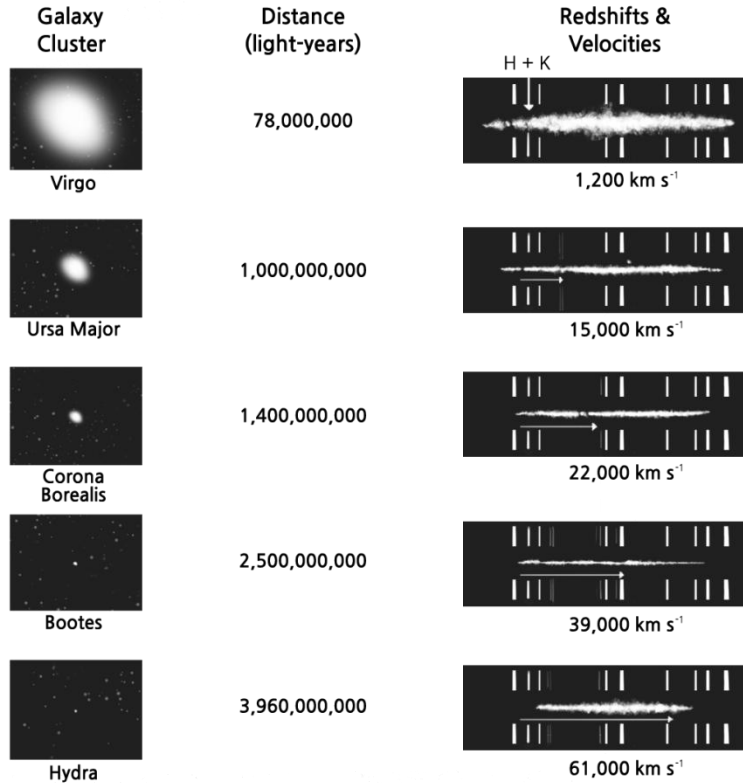
In order to investigate the matter on a much larger scale, Mr. Humason at Mount Wilson has initiated a program of determining velocities of the most distant nebulae that can be observed with confidence.



Hubble & Humason  
(1931)

# 8-3 밀튼 휴메이슨(Milton Humason)

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## 8-4 팽창하는 우주(The Expanding Universe)

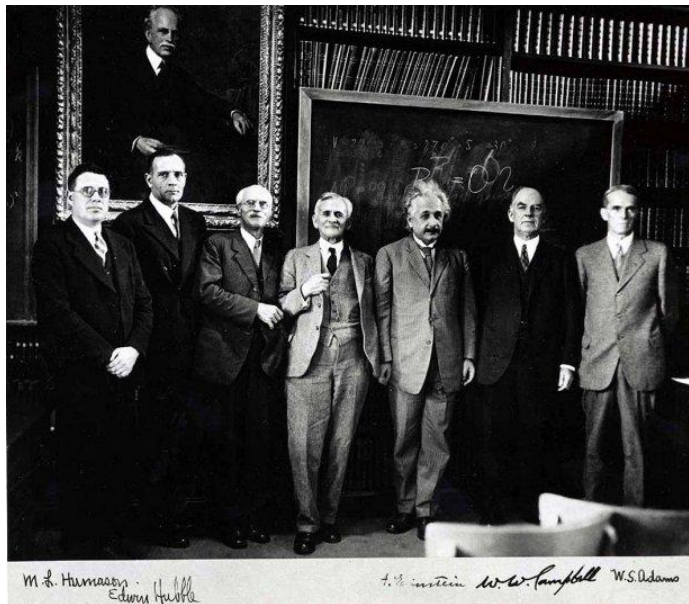
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가까운 장래에 기대되는 새로운 데이터는 본 연구의 의의를 바꿀지도 모르고, 만일 확인이 된다면 지금보다 몇 배 더 중요성을 가지는 대담으로 이어질 지도 모른다. 그래서 현재 결과의 명백한 의미를 자세히 논의하는 것은 시기상조라고 생각된다.

New data to be expected in the near future may modify the significance of the present investigation or, if confirmatory, will lead to a solution having many times the weight. For this reason it is thought premature to discuss in detail the obvious consequences of the present results.

# 8-4 팽창하는 우주(The Expanding Universe)

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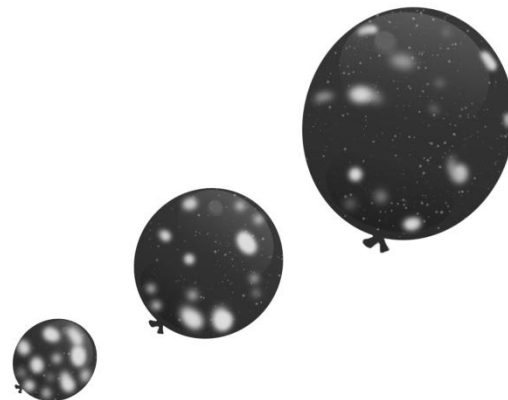
<출처>

<http://3.bp.blogspot.com/-CZ4mfKybFy4/UGqnWcTill/AAAAAAAAAIU/9sepBKlkvq8/s640/Visita+de+Einstein+en+1931+al+Monte+Wilson.jpeg>



<출처>

[https://singularidad.files.wordpress.com/2007/09/eddington\\_2.jpeg](https://singularidad.files.wordpress.com/2007/09/eddington_2.jpeg)



에딩턴

Arthur Eddington

The Expanding Universe (1933)

# Review

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The Big Bang cosmology,  
If we use the tripod analogy,  
Stands on three pillars.

The first is the expanding universe.  
The second is the cosmic background radiation.  
Together they form a strong foundation.  
Then we have cosmic elemental abundance  
Giving the model a firm stance.